Role of bank regulation on bank performance: Evidence from Asia-Pacific commercial banks

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Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy in Finance.

Abstract

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by

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As the banking industry is an essential financial intermediary, the efficient operation of banks is vital for economic development and social welfare. However, the 2008 global financial crisis (GFC) triggered a reconsideration of banking systems as well as the role of government intervention. Academic literature has paid little attention to the banking industry in the Asia-Pacific region in the context of bank efficiency. This study employs double bootstrap data envelopment (DEA) analysis to measure bank efficiency and examine the relationship between regulation, supervision, and state ownership in commercial banks in the Asia-Pacific region over the period of 2005 to 2014.

Our results indicate that excluding off-balance sheet activities in efficiency estimations lead to underestimating pure technical efficiency and overestimating the scale efficiency of banks in the Asia-Pacific region. Cross-country comparisons reveal that Australian banks exhibit the highest levels of technical efficiency while Indonesian banks have the lowest average. Our bootstrap regression results suggest that bank regulation and supervision are positively related to bank technical efficiency, while state ownership is not significantly related to bank efficiency. Furthermore, our findings show that tighter regulation and supervision are significantly related to higher efficiency for small- and large-sized banks. Before and during the 2008 GFC, tighter regulation and supervision were found to be associated with lower bank efficiency. However, the relationships between regulation and supervision become positive after the 2008 GFC, suggesting the positive impact of government intervention in the recovery of banking industries in the Asia-Pacific region.

Keywords: banks, efficiency, data envelopment analysis, Asia-Pacific, regulations

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“Be yourself. Everyone else is already taken.” Oscar Wilde

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Chapter 1

Introduction

1.1 Background

With three components of the financial system (banking, insurance, and security markets) becoming more integrated around the world, the allocation and utilisation of financial resources are affected by the operation of any one part of the financial markets. Figure 1-1 shows an overview of a typical financial system and indicates the vital role of banks play in the capital flow in the economy.

The three major functions of the banking industry are to provide liquidity and payment services, transform deposits into loans, manage various risks, and monitor investment projects (Freixas and Rochet, 2008). In the process of providing liquidation, banks provide insurance to depositors for their consumption over time (Bryant, 1980; Diamond and Dybvig, 1983). Additionally, a well-developed banking industry can satisfy the demand of capital liquidity in both the private and public sectors by undertaking a mixture of investments and providing credit for various departments and districts. By using the same fixed costs, banks are able to reduce their transaction costs through making more transactions. When banks are not involved in fund lending, borrowers have to cooperate with others to overcome their transaction costs (Santos, 2001). Furthermore, lower monitoring costs enable the banking system to satisfy capital demands and supply with lower costs than direct lending (Diamond, 1984). As one of the crucial factors of economic growth (King and Levine, 1993; Rajan and Zingales, 1998), the efficient operation of the banking system not only prompts economic development but also influences income distribution in society (Barth et al., 2004).

However, as financial institutions banks face potential bank runs and bank panics (Freixas and Rochet, 2008). The liquidation function requires banks to reserve a fair amount of capital to meet depositors' demands (Diamond and Dybvig, 1983). When depositors fear that banks are not be able to meet their needs, they will withdraw their deposits before other depositors. A large amount of withdrawals can create a liquidity shortage for banks and force those banks to sell their assets in a short period of time. Furthermore, the panic will affect the whole banking system and cause a systemic bank run (Jacklin and Bhattachaya, 1988).

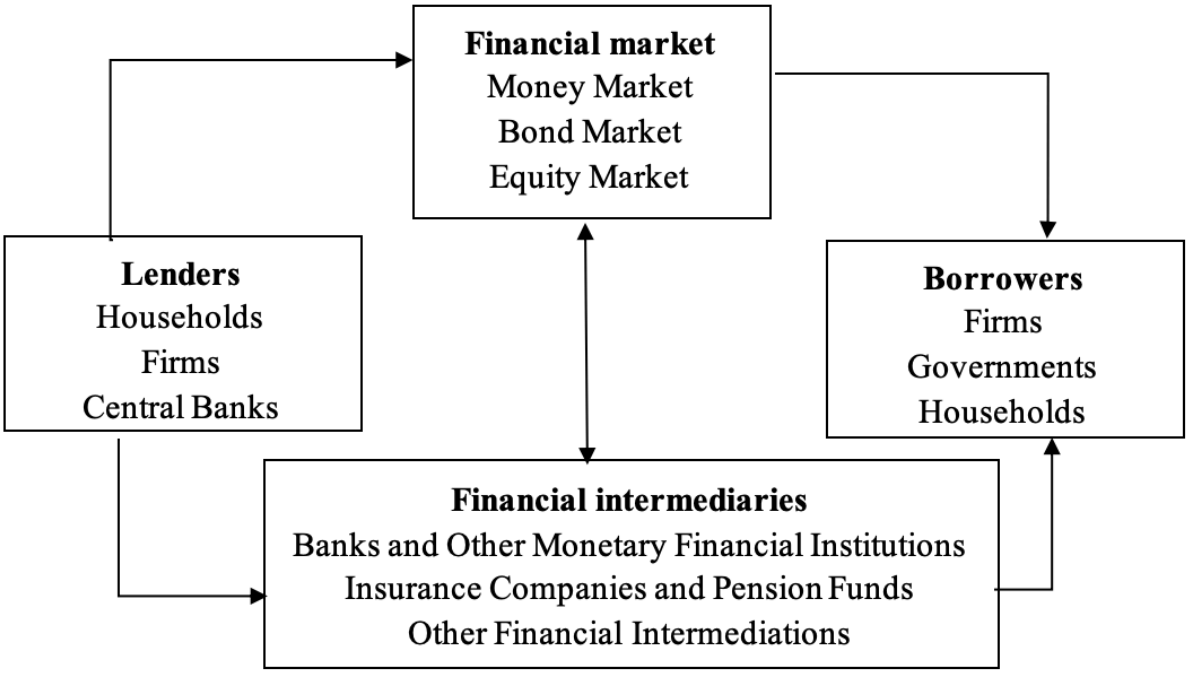


Figure 1- 1 Brief Overview of the Financial System

Source: Allen, Chui, and Maddaloni (2004)

The recent 2008 Global Financial Crisis (GFC) provides evidence that banking industries are not always stable. Before the 2008 GFC, banking industries, especially in the US, were heavily involved in the real estate bubble and credit boom. The potential risks in the banking system and recent crises have triggered a reconsideration of official interventions in the financial system (Cihak and Demirguc-Kunt, 2013). Two major government interventions are regulation and supervision and state ownership of banks.

Papanikolaou and Wolff (2014) contend that inefficient bank regulation and supervision are among the possible reasons for a fragile financial system and massive economic turmoil. Before the crisis, banks largely removed their assets off balance sheets to take advantage of regulatory arbitrage. Even though off-balance sheet (OBS) activities were originally created to help banks to garner greater profit opportunities and prepare for contingencies, they are typically associated with higher bank risks (Radic, Fiordelisi, and Girardone, 2012). Therefore, the OBS activities (DeYoung and Torna, 2013; Engle et al., 2014) and ineffective regulation of these activities (Brunnermeier, 2009) are considered possible causes of the recent 2008 GFC. Regulatory laws and supervisory policies are designed to ensure the health and sustainability of the financial system. In practice, regulation and supervision define capital standards, set requirements for entering the banking market, frame acceptable ownership structures and provide business guidelines to banks (Barth et al., 2013).

There are two main rationales for the existence of bank regulation and supervision. Firstly, regulation and supervision can control potential conflicts of interest and potential externalities in the banking system, and therefore benefit the banking industry and social welfare (Kilinc and Neyapti, 2012). Secondly, regulation and supervision can maintain the stability of fragile banking systems and function like a safety net (Kroszner, 1998) for the financial system.

Nonetheless, there are some concerns about the negative impact of regulation and supervision in the banking industry. The first problem associated with regulation and supervision is the extra costs (for example, the cost of providing a salary for regulatory staff and bank administration fees). The second problem is that it is hard to reach equilibrium between different regulatory rules. For example, bankruptcy rules must be considered when setting capital requirements (Freixas and Rochet, 2008). Despite these problems, bank regulation and supervision are still considered necessary tools for maintaining the stability of banking systems.

Since the financial crises in the 1990s, the safety net function of official regulation and supervision has been questioned; market discipline has attracted more attention as a supplement of bank regulation (Basel, 2003; Hosono, Iwaki, and Tsuru, 2004). Market discipline in the banking industry suggests that private sectors such as depositors, debt holders, and minority shareholders are more efficient in taking action on banks because of fears related to extra costs caused by banks' risky behaviour (Hosono, Iwaki, and Tsuru, 2004). However, market discipline may be less useful when private sectors believe that regulation and supervision will monitor banks on their behalf. In this case, market discipline incentives are reduced, and the private sector is less sensitive to risky bank behaviour (Dewatripont and Tirole, 1994). In 2004, Basel II established three pillars of bank regulation and supervision; minimum capital requirements, supervisory review, and market discipline. The latter two pillars are considered to be complementary methods for monitoring bank behaviour.

The financial systems in the Asia-Pacific region have undergone profound deregulation and privatisation since the 1970s. Following deregulation, banking industries in this region have experienced rapid growth, with increasing numbers of loans and investments. However, the asset price bubble in Japan (from 1986 to 1991) and the 1997 Asian Financial Crisis have struck the Asia-Pacific banking system severely, both directly and indirectly. Governments in the region implemented a series of structural changes (and/or reforms) both in the banking systems and in regards to regulatory and supervisory regimes after the financial crises. Figure 1-2 shows the changes of ratio of deposit money banks' assets to GDP (%) for selected countries in Asia-Pacific region from 1980 to 1997. Most of the economies show increasing development in the banking industries, with

Singapore, Japan, and Thailand's exhibiting rapid increase during the 1980s and other economies' rapid increase in the 1990s.

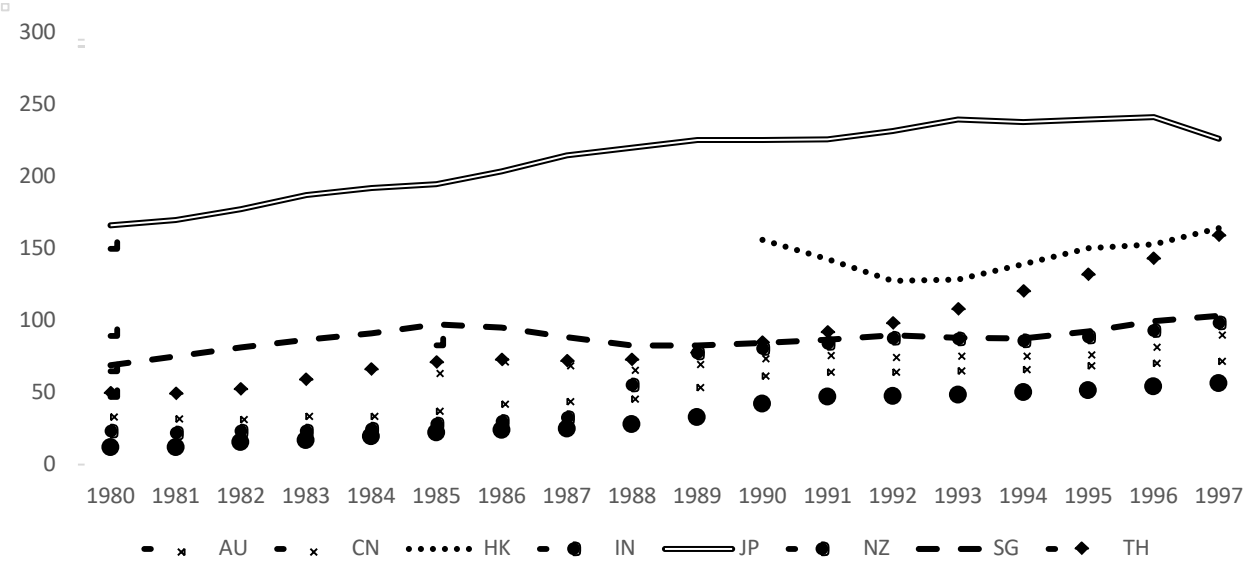


Figure 1-2 Ratio of deposit money banks' assets to GDP (%) in selected Asia-Pacific countries from 1980 to 1997

Source: World Development Indicators

Following the 2008 GFC, regulatory authorities in the Asia-Pacific region have further amended their laws and regulations to take into consideration bank risks associated with increasing innovations to maintain bank stability and increase efficiency. While most countries were in the process of implementing Basel Accord II regulations, new rules came into play. The Basel Committee on Banking Supervision (BCBS) released Basel Accord III in 2010 in response to the 2008 GFC. There have been significant achievements of the implementation of Basel III framework in many countries (KPMG, 2014). At the end of 2012, most countries in the Asia-Pacific region had fully implemented Basel II and were able to introduce Basel III regulations (IMF, 2013).

Previous studies have shown mixed empirical evidence in regards to how regulation and supervision affect the global banking industry's performance (see for example, Barth et al., 2004; 2007; 2013; Drake et al., 2006; Demirguc-Kunt and Levine, 2006; Fang et al., 2011, Pasiouras et al., 2007; 2010; 2012). For example, Berger and Bonaccorsi (2006) find that a low capital ratio is linked to higher profit efficiency for US banks, while Fiordelisi et al. (2011) argue that a well-capitalised bank can operate more efficiently. Lozano-Vivas and Pasiouras (2010) believe that non-bank activity restrictions are associated with higher profit efficiency, while Barth et al. (2001) and Demirguc -Kunt et al. (2003) show that activity restrictions increase intermediation costs and negatively affect bank efficiency. Fernandez and Gonzalez (2005) find that official supervisory power can reduce bank risk-

taking behaviour, while Beck et al. (2006) offer evidence of the positive relationship between official supervision and corruption in bank lending. In terms of market discipline, most studies support the positive role of regulation to promote market discipline in relation to bank performance (Lozano-Vivas and Pasiouras, 2010; Gaganis and Pariouras, 2013; Luo et al., 2016, etc.). However, Chortareas et al. (2012) find that excessive market discipline may adversely affect bank efficiency.

As discussed previously, one other important method of government intervention in the banking industry is through state ownership in banks. State ownership has been widely observed in the banking industry around the world. The degree of state ownership depends on factors such as economic and financial development, property rights, and financial openness (La Porta et al. 2002). Theoretically, there are two views about government ownership in financial markets; development and political views. The development view argues that some financial markets are not sufficiently developed for banks to be functional. Therefore governments need to participate in financial institutions to help the country's financial and economic development (Gerschenkron, 1962). In the political view, state ownership in the banking industry is a way for politicians to control banks and achieve their political objectives. When the government owns the bank, they will allocate capital resource to their supporters and gain votes (Shleifer and Vishny, 1994; Shleifer, 1998).

The empirical evidence has provided opposing results relating to the relationship between state ownership and bank performance. Most of the studies find that a higher level of state ownership is related to more bank fragility (Caprio et al., 2002), lower efficiency and development (Barth et al., 2001; 2004) and lower productivity growth (La Porta et al., 2002). In conjunction with the political view, Iannotta et al. (2013) suggest that government safety net functions are strengthened during election years and that state-owned banks have lower default risks but higher operating risks than their privately-owned counterparts. Supporting the development view, some previous studies find that state-owned banks have better performances than privately-owned banks (see for example, Omran, 2007; Chen et al., 2005, Dong et al., 2014).

1.2 Motivation for the Research

Compared to those in other countries, the Asia-Pacific banking systems has some unique characteristics. Firstly, countries in this region have various institutional setups, including financial markets, legal traditions, bankruptcy codes, and ownership structures (Lee et al., 2015). For example, Australia, Singapore, and New Zealand are members of the British Commonwealth and have a few common characteristics in their rules of law, accounting practices and corporate governance. Second, based on their development status, countries such as Australia, Singapore, New Zealand, and Japan are more developed and therefore have more sophisticated banking sectors. In contrast, China, Indonesia, and Thailand belong to emerging markets and have less advanced banking systems

(Deesomsak et al., 2004). The diversity of the operating environment for the banking industry offers an ideal setting for this research.

The recent 2008 GFC caused significant financial turmoil, equal or greater to that of the Great Depression in the 1930s in the US. The GFC differs from previous crises, because it affected mostly advanced economies (Laeven and Valencia, 2012). Even though the economic growth in most countries around the world have been through downturns during and after the crisis, countries in the Asia-Pacific region have decoupled themselves with strong resilience from other countries. Figure 1-3 exhibits the average annual GDP growth rates of selected countries in the Asia-Pacific region and other regions from 2005 to 2014. Compared to European, the OECD, and the world average levels, the Asia-Pacific countries have shown a milder decrease in GDP growth in 2008 and 2009. Over the 10-year period, Asia-Pacific countries have maintained higher levels than other regions. Furthermore, none of the Asia-Pacific countries have been classified as one of the crisis countries in the 2008 GFC (Laeven and Valencia, 2012).

Figure 1-3 GDP Growth Rates (Annual %) of Selected Regions from 2005 to 2014

Source: World Development Indicators, World Bank

Compared to other countries, most countries in the Asia-Pacific region have a bank-dominated financial system. Figure 1-4 illustrates the comparisons between the overall domestic credit to private sector and those provided by banks for selected regions from 2005 to 2014. Compared to the US, and the average world levels, banking systems in Asia-Pacific have provided more than half of the credit loaned to the private sectors over the period, suggesting the prevailing role of banking sectors in financial systems.

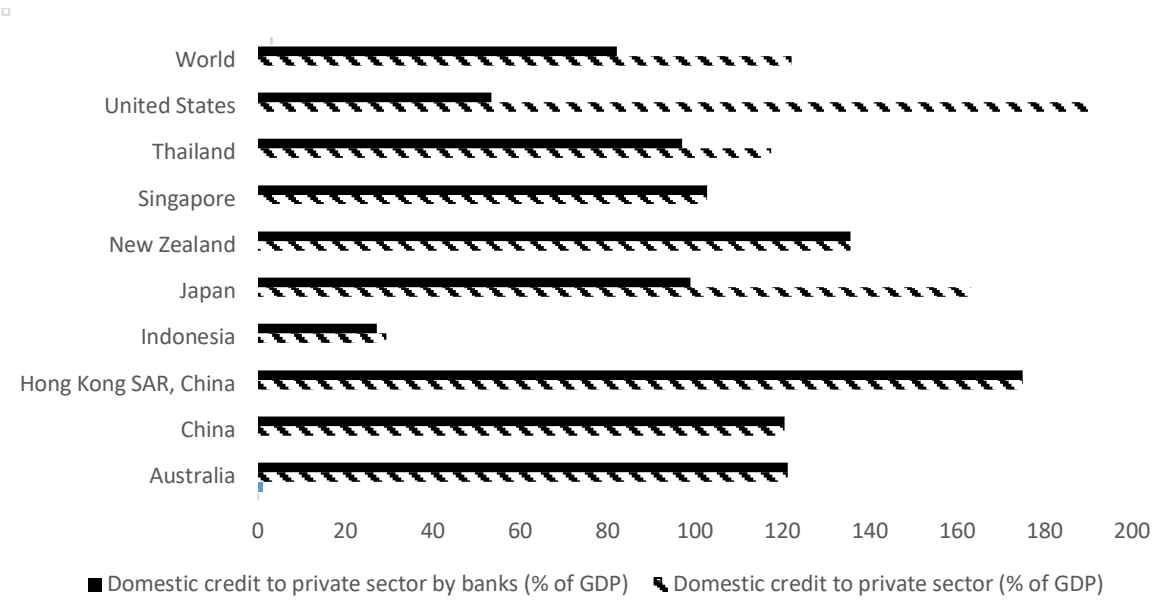


Figure 1-4 Domestic Credit to Private Sector in Selected Countries

Source: Global Financial Development Database, 2014.

Since the 1997 Asian Financial Crisis (AFC), the banking industries in the Asia-Pacific region have shown strong performance due to profound deregulation and reforms. The 1997 AFC also contributed to the creation of a solid foundation for the Asia-Pacific banking system (IMF, 2013). During the 2008 GFC, banks in the Asia-Pacific region demonstrated their strong performance and resilience, which can be explained by their low exposure to securitised assets, strong bank balance sheets, and effective and timely government intervention. From 2007 to 2014, the average return on assets ratios of Asia-Pacific banks was 13%, which was higher than the global average. Additionally, before the 2008 GFC, there was no bank from the Asia-Pacific region (except Japan) in the top 10 banks around the world. By 2013, four Chinese banks were among the top 10 largest banks (Ernst and Young, 2017). All the unique characteristics of bank performance and financial development in Asia-Pacific have provided an ideal setting to conduct research into the banking industry and examine whether regulation and supervision benefit bank performance.

Of all the efficiency estimation approaches, the data envelopment analysis (DEA) approach is the most commonly used in bank efficiency studies (Fethi and Pasiouras, 2010). Bank efficiency is typically defined by its ability to transform inputs into outputs given the available production technology. However, there have been debates about the selection of inputs and outputs.

The production and intermediation approach are the two principal approaches used to specify inputs and outputs in the banking industry. The production approach assumes that banks use labour and capital to produce loans and deposits. The intermediation approach, however, believes that banks absorb deposits and use the funds for lending (Berger and Humphrey, 1997). Recent bank studies

have questioned whether non-traditional activities should also be considered as outputs (Clark and Siems, 2002; Lieu et al., 2005; Pasiouras, 2008; Lozano-Vivas et al., 2014). Low exposure to innovative financial products is considered to contribute to the high performance of the Asia-Pacific banking industry. Therefore, it is essential to investigate whether it is necessary to include off-balance sheet activities in bank efficiency estimations in this region.

As O'Donnell et al. (2008) indicate, a common problem in previous cross-country studies is that all of the sample banks are assumed to be homogenous. Likewise, bank efficiencies are estimated relative to the common frontier. However, regulation, macroeconomic, and other external environmental factors make it unreasonable to assume the same frontier. This study follows O'Donnell et al. (2008) in evaluating the distance between group-frontiers to the meta-frontier of the Asia-Pacific region, providing more information on the efficiency of the banking industry in one country.

Even though there are cross-country studies in the banking industry in the Asia-Pacific region (Sathye, 2005; Fu et al., 2014; Lee et al., 2014), none provide evidence to justify the inclusion of off-balance sheet activities in outputs. Moreover, there are no conclusive results on the relationship between bank regulation, supervision, and bank efficiency in the Aisa-Pacific region after the 2008 GFC.

1.3 Research Problem Statement

This current study measures bank efficiency in terms of non-traditional activities. More specifically, it examines the relationship between bank efficiency and government interventions; regulation, supervision, and state ownership in the banking industry over the period of 2005 to 2014.

The research questions are:

1. Do the off-balance sheet activities have an impact on bank efficiency measurements in the Asia-Pacific region?

2. Are bank regulation and supervision significantly related to bank efficiency in the Asia-Pacific region?

3. Is state ownership significantly associated with bank efficiency in the Asia-Pacific region?

1.4 Research Contributions

The efficient operation of the banking industry is especially crucial for bank-dominated countries in the Asia-Pacific region given their essential role as intermediaries. Therefore, correct measurements of bank efficiency can provide precise information about the banking sector. It is vital to identify the

factors affecting bank efficiency. Moreover, among other factors, government intervention, has been questioned since the 2008 GFC.

To the best of our knowledge, there are limited studies on bank performance, regulation and supervision in the Asia-Pacific region. Most of the previous literature has been conducted in the US and European banking industries.

Except for studies on the global banking industry (see for example, Levine, Caprio, and Barth, 1999; Barth et al., 1998, 2001; 2004; 2010; 2013; Pasiouras, 2008; Pasiouras et al., 2009; Lozano-Vivas and Pasiouras, 2010; Gaganis and Pasiouras, 2013; Luo, Tanna, and DeVita, 2016), and the Asian banking industry (see for example, Laeven, 1999; Barry et al., 2008; Gardener, Molyneux, and Nguyen-Linh, 2011; Chen and Yang, 2011; Lin et al., 2016), only a few studies (see for example, Sathye, 2005; Fu, Lin, and Molyneux, 2014; Lee et al., 2014) provide cross-country evidence of bank performance, bank regulation, supervision, and state ownership in the Asia-Pacific region.

Moreover, bank efficiencies are measured relative to the production frontier which is enveloped by all of the sample banks. Even though previous studies provide efficiency scores for banks in the Asia-Pacific region, the usefulness of this information is questionable for different samples and study periods.

While most previous studies include off-balance sheet (OBS) activities as one of the outputs when estimating bank efficiency (see for example, Drake, 2001; Drake and Hall, 2003; Sturm and Williams, 2005; Hadad et al., 2011, Radic, Fiordelisi, and Girardone, 2012), limited studies have discussed and justified the inclusion of OBS activities (Lieu et al., 2005; Pariouras, 2008; Lozano-Vivas and Pasioura, 2010; Lozano-Vivas and Pasiouras, 2014). This study is the first to examine whether the inclusion of OBS activities in bank efficiency measurement is necessary and how the incorporation of OBS activities affect bank efficiency scores.

Bank efficiency is highly dependent on measurement methods, input and output specifications, and sample banks, which are used to envelop the production frontier. Efficiency measurement is only comparable to banks sharing the same frontier. As the first study focusing on the Asia-Pacific region, this study provides comparable information to evaluate bank performance in the region. Another contribution of the efficiency estimation is that this study employs Simar and Wilson (2007)'s double bootstrap DEA approach to avoid potentially incorrect interpretations of the regression results. Additionally, we follow O'Donnell et al. (2008) and use the technology gap ratio to measure the distance between best-practice banks of each country to the best-practice banks in the Asia-Pacific region. This information can provide more insight into each country's banking industry.

The 2008 GFC has affected bank operating environments, both in terms of regulation and supervision, and macroeconomic conditions. This study is the first to consider the impact of bank regulation and supervision, and state ownership on bank efficiency, in both pre- and post-crisis periods, in the Asia-Pacific region.

Using correctly-estimated efficiency measures, researchers and policymakers are able to evaluate the baking industry in each country and make suitable policies to promote financial and economic development in the Asia-Pacific region. Moreover, our empirical evidence of the relationship between regulation, supervision, state ownership and the bank efficiency can provide essential information for governments and regulatory authorities for policy-making in the future.

1.5 Organisation of the Thesis

The remainder of the study is organised as the follows: Chapter 2 provides an overview of the Asia-Pacific banking industries, including developments in bank reform, regulations, and supervisory schemes. Chapter 3 presents the literature on bank efficiency and/or bank regulation, supervision, and state ownership. Chapter 4 describes the double bootstrap DEA approach employed in this study. Chapter 5 discusses the empirical results and provides answers to the research questions. Lastly, Chapter 6 concludes the study and discusses the study's limitations and future research directions.

Chapter 2

Overview of Banking Industries in the Asia-Pacific Region

2.1 Introduction

Chapter 2 provides a brief overview of the banking industry in the Asia-Pacific region. Section 2.2 briefly introduces the overall banking industry of the Asia-Pacific region. Sections 2.3 to 2.10 describe the development and regulation of the banking industry for each of the study's sample countries[1]. For each country, we employ two commonly used indicators to characterise banking system performance. The return on assets ratio is used to measure profitability, while loan loss provision relative to loans covers asset quality. Section 2.11 concludes the chapter.

2.2 The Banking Industry in the Asia-Pacific Region

The banking system has dominated the financial system and has played a vital role in the economic development of the Asia-Pacific region over the previous two decades. Before the 1997 Asian Financial Crisis, the Asia-Pacific region experienced rapid economic growth relative to the US and European countries. Over the period of 1990 to 1996, the region also experienced significant foreign capital inflow, high levels of domestic consumption, booming investments, and credit expansion.

However, impotent regulation and supervision during this period of financial deregulation and reform exposed the system's weaknesses (Fu, Lin, and Molyneux, 2014) in this region. Except for Australia, most economies in this region were severely affected severely by the 1997 AFC. More specifically, South Korea, Indonesia, Malaysia, and Thailand were directly affected, while Hong Kong, Singapore, and Japan experienced crises indirectly and experienced negative economic growth during this period. Following the 1997 AFC, governments in the region began a series of structural reforms and prudential regulatory policies to revive the economy and financial industry. Government interventions in this region have reduced non-performing loan levels significantly and improved the banking industry's profitability and liquidity.

Banks in this region have also raised their capital ratios in compliance with more conservative regulatory policies (Capannelli and Filippini, 2009). After the 2008 GFC, the Asia-Pacific banking industry has maintained a high return on assets (ROA) ratio. As of the end of 2014, the ROA in the

[1] Eight countries (or region) are selected in this study based on data availability in either bank-specific data or regulatory data. For example, BvD Bankscope provides data for banks in South Korea and Malaysia from 2010. However, World Bank Regulatory and Supervisory Survey did not provide regulatory data for countries such as Vietnam.

Asia-Pacific region was almost twice that of the rest of the world; this has largely been attributed to the rapid growth of the Chinese and Indonesian banking sectors (McKinsey, 2016).

2.3 Overview of the Banking Industry in Australia

As defined by the Australian Prudential Regulation Authority (APRA), an authorised deposit-taking institution (ADI) is a body corporate that is allowed to conduct banking business in Australia. Banks are one major component of the ADIs. Other ADIs in Australia include building societies, credit unions, and other types of ADIs. At the end of 2017, there were 147 ADIs in Australia, of which 84 were banks. Banks account for 98% of the total assets of ADIs (Reserve Bank of Australia, 2017) in Australia. Based on effective stability settings, the Australian financial system has shown resilience during the recent 2008 GFC (Financial System Inquiry, 2014). There are several characteristics in the Australian banking sector. Firstly, the banking system is predominantly privately-owned and operates under market-based principals. Secondly, the banking sector is highly concentrated. The four major banks (that is, the Australia and New Zealand Banking Group Limited, the Commonwealth Bank of Australia, the National Australia Bank Limited, and the Westpac Banking Corporation) are the most significant components of the financial system and have great market influence in Australia.

In 1981, the Australian Financial System Inquiry (Campbell Committee) recommended deregulating the financial system. They believed that financial deregulation would benefit the entire Australian economy and improve the efficiency of the banking system at large (Swan and Harper, 1982). Following this recommendation Australia began a series of reforms in the financial sector. In December 1982, the Australian dollar was floated, and the exchange rate control was removed. Following deregulation of the currency, more liberalisations were implemented. These included eliminating previous deposit controls, loosening restrictions on foreign banks' entry into the market, and starting authorisation of savings banks to provide checking facilities in the banking system. Since then, the Australian banking sector has experienced rapid development. During the 1990s, the Australian banking industry was transformed from a traditional intermediary to a comprehensive financial service provider (Kirkwood & Nahm, 2006). The most remarkable outcome of these financial reforms is the continual economic growth in Australia (until the GFC in 2008). Deregulation has not affected regulation in the banking system. On the contrary, as a result of proper supervision (Pomfret, 2009) and well-capitalised banks (Hawtrey, 2009), the Australian banking sector performed much better than other countries during the 2008 GFC. However, the Australian regulatory authority – the Australian Prudential and Regulatory Authority (APRA) – has still been criticised for acting ineffectively during the crisis, since their main intervention related to banks' non-performing assets (Forughi, 2012).

As can be seen in the information in Figure 2-1, profitability of the Australian banking industry, measured by return on assets (ROA), has witnessed a decline from 2005 to 2009. The ROA ratio showed a mild increase in 2010 and remained below 1% from 2010 to 2014. Non-performing loan levels increased rapidly in 2008, implying a deterioration in bank asset quality due to global financial turmoil. Despite modest decreases since 2010, the overall non-performing loan ratios between 2008 and 2014 were still higher than before 2007.

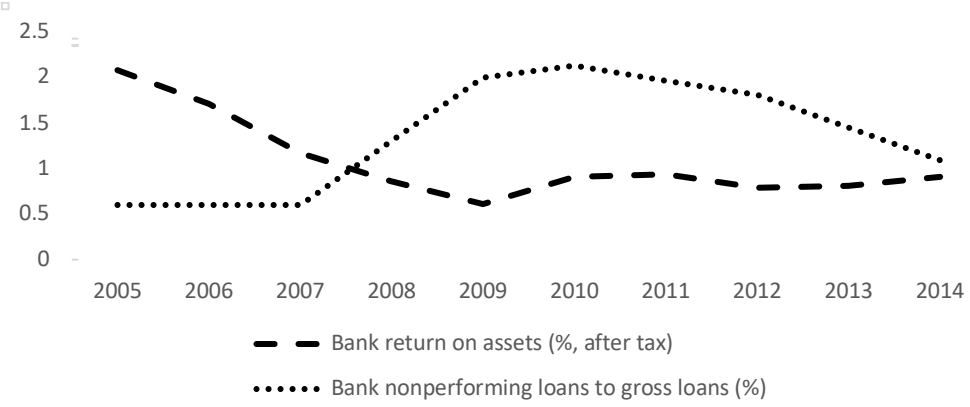


Figure 2-1 Profitability and Asset Quality of the Australian Banking Industry

Source: Global Financial Development Database (2014)

2.4 Overview of the Chinese Banking Industry

The establishment of the People's Bank of China (PBOC) in 1948 marked the commencement of the current Chinese banking system. Since then, the PBOC has functioned as the central bank, and the only commercial bank in China. The centralised planning economy in China started to transform into a market-based economy in 1978. From 1979 to 1988, the banking system was allowed to be more active in the domestic economy. A two-tier banking system was built to replace the mono-bank system, and four specialised state-owned commercial banks became functional and more independent from the PBOC. The four specialised banks are the Bank of China (established in 1912 and re-opened in 1979), the Construction Bank of China (established in 1954 and re-opened in 1983), the Agriculture Bank of China (established in 1979), and the Industrial and Commercial Bank of China (established in 1984). Since economic reforms in 1979, the Chinese banking sector has undergone significant changes and development. In the meantime, the PBOC assumed the role of central bank in regulating specialised banks, non-bank financial institutions, and insurance companies.

The competitive and contemporary Chinese banking system was built after the enactment of the new Central Bank Law and Commercial Bank Law in 1995. Since then, Chinese bank regulation and supervision have followed the Basel Committee on Banking Supervision (BCBS) principals. Notwithstanding, the four largest commercial banks were still involved in policy lending, as directed

by central and local governments during this period. Meanwhile, the joint-stock commercial banks developed rapidly. For example, the largest joint-stock bank, the China Merchant Bank (established in 1987), was ranked as the fourth most profitable bank in 2000, followed by the state-owned Agriculture Bank of China (Chen, Skully, and Brown, 2005). To join the World Trade Organisation (WTO), there have been more reforms in the banking industry. The most noteworthy one relates to historically accumulated non-performing loans in the four largest state-owned commercial banks - these were peeled from their balance sheets after 1999. More capital was injected into the banking system to deal with policy-related non-performing loans. Furthermore, the four largest commercial banks were transformed from wholly state-owned to joint-stock through initial public offerings (IPOs) in the Shanghai and Hong Kong Stock Exchange (Wang et al., 2014). As of the end of 2010, all four state-owned banks completed IPOs and became publicly listed banks.

Another significant event in the banking industry is that the role of PBOC as bank regulatory authority was handed over to the newly-established China Banking Regulatory Commission (CBRC) in April 2003. The CBRC is responsible for prudential regulation, depositor protection, and maintaining the stability of the banking system. Moreover, to encourage foreign entry and increase competition in the banking industry, CBRC updated its guidelines and now allows foreigners to own up to 25% of domestic banks. After the 2008 GFC, the CBRC introduced new regulations, such as higher capital ratio requirements, and new leverage ratios, to control asset quality problems in the banking industry (He, 2013).

As of the end of 2016, there are three policy banks, five large commercial banks (the big four commercial banks and the Bank of Communication), 12 joint-stock commercial banks, and 134 city commercial banks. The five largest banks account for 37.3% of the total assets of the banking system (CBRC, 2016). The CBRC has been working to build a prudential regulatory regime, which will meet current international standards. The first notice concerning Basel II implementation was made in October 2011. In 2011, CBRC announced new regulation proposals, which were more stringent than Basel III (Cousin, 2012)

As can be seen in Figure 2-2, bank profitability in China increased slowly from 2005 to 2014. It was not significantly affected by the 2008 GFC. Due to continuous efforts in asset quality management, the bank non-performing loans ratio has dropped dramatically from 2005 to 2010. It has remained at a low level from 2011 to 2014. Although financial reforms associated with problematic assets have improved considerably, a significant proportion of non-performing loans in the Chinese banking industry are still from state-owned commercial banks (CBRC, 2009).

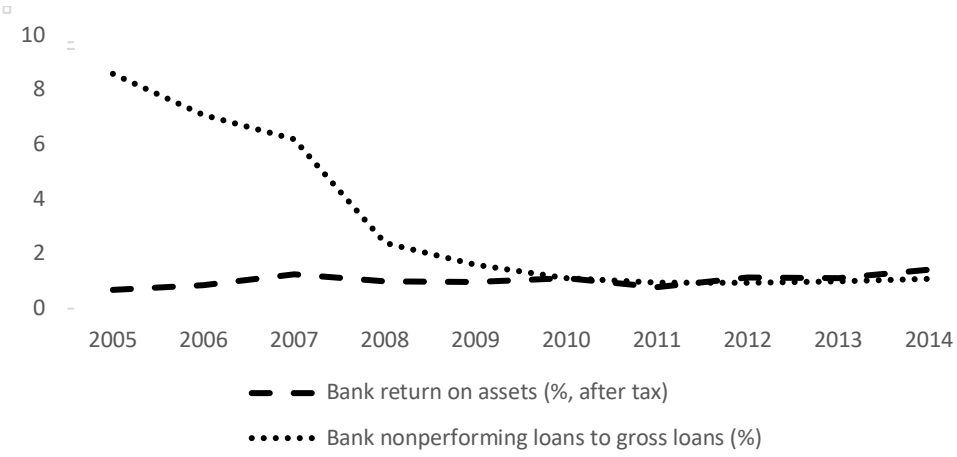


Figure 2-2 Profitability and Asset Quality of Chinese Banking Industry

Source: Global Financial Development Database (2014).

2.5 Overview of the Hong Kong Banking Industry

The Hong Kong economy has grown strongly in the Asia-Pacific region and become one of the key international financial centres worldwide. In 1990, the Hong Kong banking system changed from a monolithic system of licensed banks to a three-tier banking system (Drake et al., 2006). The new banking system consists of three types of authorised deposit-taking institutions[2] (AIs): licensed banks, restricted licensed banks, and deposit-taking companies. As of the end of 2017, there are also 57 representative offices of foreign banks in Hong Kong (The Hong Kong Monetary Authority, 2017).

According to IMF (2014), the quality of macro-prudential and macro-prudential oversights (for example, the intensity of supervision, comprehensiveness of risk assessment, and active use of macro-prudential policies), helped to ensure the resilience of the Hong Kong banking system during the 2008 GFC. The total assets of the banking system were equivalent to 249.25% of the GDP and ranked as the highest among financial systems worldwide (IMF, 2014).

The most recent stage of financial deregulation in Hong Kong began in 1995 and was completed by July 2001 when the deposit interest rate cap was removed. In July 1997, Hong Kong was handed over to Mainland China as a former British colony. Since the handover, the Hong Kong banking industry has been increasingly dependent on Mainland China, both economically and financially. In 2006, a formal deposit insurance scheme was introduced in Hong Kong. The deposit insurance has attracted a large number of smaller-sized banks into the system and increased the competition in the sector (Drake et al., 2006).

[2]. All of the deposit-taking institutions in Hong Kong are collectively known as authorised institutions.

The Hong Kong Monetary Authority (HKMA) is responsible for regulating the banking system to ensure that banks operate in an effective, responsible, honest and business-like manner and that depositor interests are adequately protected (HKMA, 2003). HKMA has successfully fulfilled the objective of regulation and supervision and was one of the early adopters of the international regulatory standards in capital, liquid, and risk management (IMF, 2014).

The Hong Kong banking industry features (from 2005 to 2014) are shown in Figures 2-3. From 2005 to 2007, the non-performing loan ratio dropped continually, which suggests improved asset quality. Affected by the 2008 GFC, the non-performing loan ratio increased rapidly from 2008 to a high level of 1.6% in 2009. From 2010, bank asset quality improved, with non-performing loan ratios decreasing to their lowest level (0.51% over the 10-year period ending 2014). In Hong Kong bank profitability increased from 2005 to 2006 and dropped from 2007 to 2008. Since 2009, the ROA ratio has remained stable and experienced a modest rise from 1.14% in 2012 to 1.3% in 2013. This decreased to 0.96% in 2014. This decline in profitability in 2014 is due primarily to increases in average assets and a reduction in after-tax profits (HKMA, 2014).

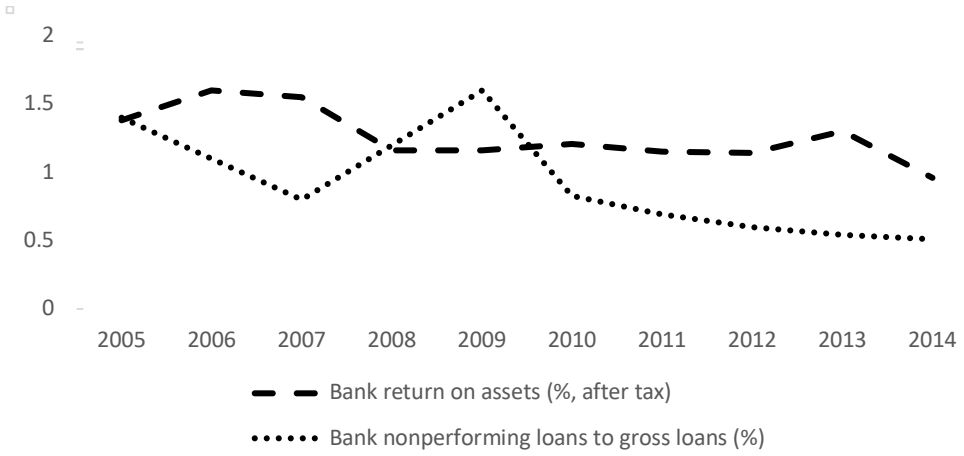


Figure 2-3 Profitability and Asset Quality of the Banking Industry in Hong Kong, SAR

Source: Global Financial Development Database (2014)

2.6 Overview of the Indonesian Banking Industry

Following the independence of Indonesia in 1949, the nationalisation of the Dutch banks in Indonesia symbolised the beginning of the Indonesian banking system. During the 1950s, the country established a banking sector consisting of domestic commercial banks and foreign banks. In the following two decades, the banking system developed rapidly, especially in terms of state-owned banks. State-owned banks were protected by the policy that state-owned enterprises were required to deposit their funds only into state-owned banks. In 1966, after experiencing hyperinflation, the

Indonesian government announced an economic stabilisation programme designed to reduce its deficit, liberalise the exchange rate, and control bank credit (Margono et al., 2010).

Deregulation of the Indonesian financial system began in 1983 when credit ceilings and interest rate controls were removed. Furthermore, joint-stock banks were allowed to enter into the banking system in 1988. Around the same time, state-owned enterprises were allowed to deposit their money into private banks rather than only into state-owned banks (Pangestu and Habir, 2002). Between 1988 and 1993, the number of Indonesian banks doubled. However, deregulation has not been without its problems. Due to increasing competition, banks began to take more risks and expanded their lending. The removal of interest rate controls also contributed to a considerable influx of capital from overseas; as a result the banking sector became extremely vulnerable to external shocks. Without an effective regulatory and supervisory system, bank credit continued to flow into high-risk investment projects, like those in the real estate sector (Creed, 1999; Montgomery, 1997). With increasing numbers of default real estate loans, the non-performing loans accumulated rapidly in the Indonesian banking industry. The overheated financial system eventually ended with a currency crisis in 1997. By the end of 1997, the Indonesian Rupiah had depreciated by 80% and 16 banks went bankrupt. To recover the domestic economy, the newly-established Indonesian Banking Restructuring Agency restructured the banking industry; by the end of 1999 66 out of 239 banks had been closed (Suta and Musa, 2003; Margono et al., 2010).

Before the establishment of OJK (Otoritas Jasa Keuangan or the Indonesian Financial Services Authority) in 2011, the Bank of Indonesia was the central bank and bank regulatory authority. OJK assumed bank oversight responsibilities at the end of 2013 and became the primary regulatory authority of the financial system. OJK's responsibilities include prudential regulation and supervision of banks, insurance companies, pension funds, finance companies, and securities firms (OJK, n.d.). In cooperation with OJK, the Bank of Indonesia fully implemented Basel II accords in Indonesia by the end of 2012.

Between 2011 and 2016, the Indonesian banking industry experienced rapid asset growth at a compound annual growth rate of 13%, which was attributed mainly to the underpenetrated banking market (Ernest and Young, 2017). At the end of 2015, commercial banks' total assets were equivalent to 55% of GDP. The current Indonesian banking industry has a high concentration of state-owned and regional development banks, which hold the majority of the market shares. The four largest state-owned banks (that is, Bank Mandiri, Bank Rakyat Indonesia, Bank Negara Indonesia, and BNT) accounted for almost half of the total bank assets in Indonesia by the end of 2016 (World Bank, 2017).

As shown in Figure 2-4, the Indonesian banking industry demonstrates high and stable profitability from 2005 to 2014. Except for the low value of 1.13% in 2008, the ROA ratios remained above 1.5% and increased to over 2% in 2010. Another improvement in the Indonesian banking industry is good asset quality management over the 10-year period ending 2014. The non-performing loans ratio decreased from 7.6% in 2005 to 1.69% in 2013. This was followed by a slight increase to 2.07% in 2014, suggesting the resilience and development of the Indonesian banking industry.

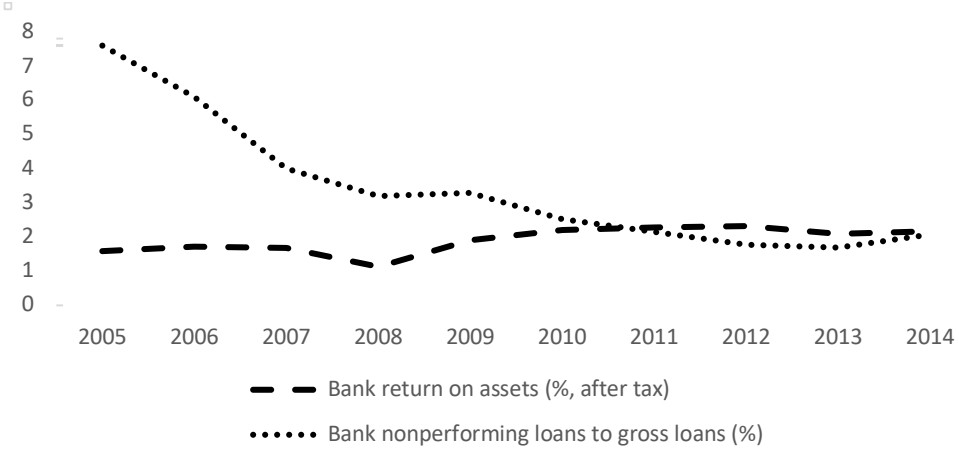


Figure 2- 4 Profitability and Asset Quality of the Indonesian Banking Industry

Source: Global Financial Development Database (2014)

2.7 Overview of the Japanese Banking Industry

The Japanese financial system has historically been regarded as one of the most sophisticated systems in the world. In 2016, the total assets of the financial system were worth around 620% of the country's GDP, half of which came from the banking system (IMF, 2017). According to the Bank of Japan, Japanese commercial banks can be categorised into city banks, regional banks, member banks of the Second Association of Regional Banks (Regional banks II), foreign banks, trust banks, bank holding companies, and other banks. Even though there are 110 banks in Japan (the Japanese Bankers Association, 2018), the three megabank groups (that is, Mitsubishi UFJ Financial Groups, Mizuho Financial Groups, and the Sumitomo Mitsui Financial Group), controlled nearly half of the total assets of the financial system as of the end of March 2012 (Moody's, 2016).

Financial liberalisation in Japan began in the early 1970s. A formal deposit insurance scheme was introduced in Japan in 1971. Soon after, in 1979, interest rate liberalisation increased interest rate flexibility for commercial banks. However, after rapid growth following deregulation, Japan experienced a severe asset price bubble burst in the 1980s. Since then, the Japanese economy has faced a number of problems, including deflation issues, weak property markets, and unstable stock markets. All of these issues have created an unfavourable operating environment for the banking

sector (Oyama and Shiratori, 2001). A significant amount of problem loans were accumulated during the asset price bubble burst (Mamatzakis, Matousek, and Vu, 2016).

To deal with problem loans in the banking industry, Japanese authorities undertook several restructuring packages. From 1998 to 2009, more capital funds were injected into the banking system (Montgomery and Shimizutani, 2009). In 2000, the Financial Supervisory Agency was renamed as the Financial Services Agency (FSA) and became the main regulatory body for supervising commercial banks. The Bank of Japan has retained its role as the lender of last resort and is involved in on-site inspections and off-site monitoring (Bebenroth et al., 2009). Even though the FSA announced that banks were required to liquidate their shares in poor performing companies in 2002, shares which were not liquidated were sold to the Bank of Japan. Furthermore, the government allowed banks to temporarily record holding stocks in firms and real estate companies as book or market values to increase the value of banks' assets during the asset price bubble collapse. This policy ceased in 2002 when banks were required to switch back to recording shares using book values. Apart from government interventions, there has been an intense wave of bank consolidation. These mergers and consolidation have helped to stabilised the banking system and effectively reduce risks (Harada and Ito, 2011).

Bank profitability has been at a lower level due to the narrowing of the deposit and lending margins under continued low-interest rates, increased competition in the financial system (Bank of Japan, 2018), and weak domestic credit demands (IMF, 2017). There was an increase in the ROA ratio from 2005 to 2006, which then decreased to a negative level; 0.13% in 2009. Bank profitability increased in 2010 and remained around 0.3% until 2014. The non-performing ratio of the Japanese banking industry remained at a low level from 2005 to 2007 and grew to 2.4% in 2008. The ratio level of 2.4% remained from 2009 to 2013, until a recent decrease in 2014 to 1.93%.

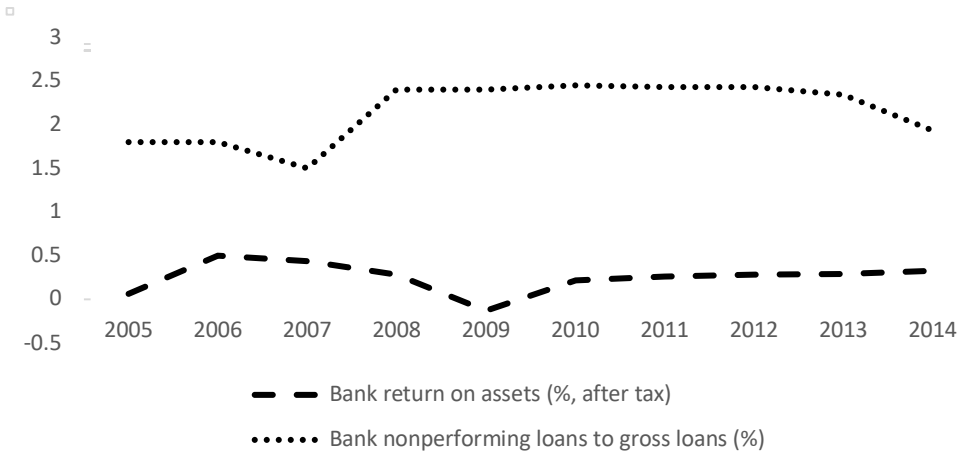


Figure 2- 5 Profitability and Asset Quality of Banks in Japan

Source: Global Financial Development Database (2014)

2.8 Overview of the New Zealand Banking Industry

Similar to other Asia-Pacific countries, the New Zealand banking system dominates the financial sector and is highly concentrated. An important attribute, which differentiates New Zealand from other economies, is the high proportion of foreign ownership in the banking industry (Tripe, 2003). There are 26 registered banks in New Zealand, among which the four largest banks (that is, ANZ Bank, ASB Bank, the Bank of New Zealand, and Westpac) account for 87% of the total lending from the banking industry, as of the end of 2017. Additionally, the four largest banks are Australian-owned. There are currently 5 New Zealand-owned banks (Kiwibank, SBS Bank, TSB Bank, the Co-operative Bank, and Heartland Bank), which represent only 8% of bank lending. At the end of March 2018, the total assets of the banking system are over NZ$ 527 billion, equivalent to 186% of New Zealand's GDP (Reserve Bank of New Zealand, 2018).

The financial deregulation of New Zealand brought significant changes to the banking system in the 1980s. Before deregulation, trading banks dominated the banking sector in New Zealand. There were some other domestically-owned financial institutions, such as building societies, financial companies, and the Rural Bank. During deregulation, barriers to entry and exit in the banking system were loosened. The bank registration system was established in 1986. With relatively free entry, foreign ownership in the banking industry increased exponentially, following the acquisitions of domestic banks by foreign banks. When the Westpac Banking Corporation acquired Trust Bank New Zealand in 1996, almost 99% of the total assets of the New Zealand banking industry were foreign-owned (Tripe, 2003). In response to the 1997 AFC, the New Zealand banking industry went through a fast-paced consolidation. The most recent of these, ANZ Banking Group's (New Zealand), acquisition of the National Bank, occurred in 2003.

The 2008 GFC has demonstrated the resilience of the New Zealand banking industry. There are two main reasons, which explain why New Zealand banks weathered the external shocks well during the global financial turmoil. Firstly, business in the New Zealand banking system has traditional been lending to households and rural sectors, instead of involving financial innovations such as asset securitisations. Secondly, New Zealand's conservative banking regulatory regime has enabled banks to maintain an effective risk management system (Bollard, Hunt, and Hodgetts, 2011).

The Reserve Bank of New Zealand (RBNZ) is responsible for prudential regulation of the country's financial institutions. Regulation and prudential supervision are designed to maintain a sound and efficient financial system. With high levels of foreign ownership in the banking system, RBNZ keeps a close relationship with the Australian Prudential Regulation Authority (APRA). The Trans-Tasman

Council on Banking Supervision (TTC) was formed in February 2005 to assist with the development of a single trans-Tasman economic market in banking services (Putnis, 2012). The TTC requires APRA and RBNZ to assist each other in meeting their statutory responsibilities related to prudential supervision (RBNZ, n.d.).

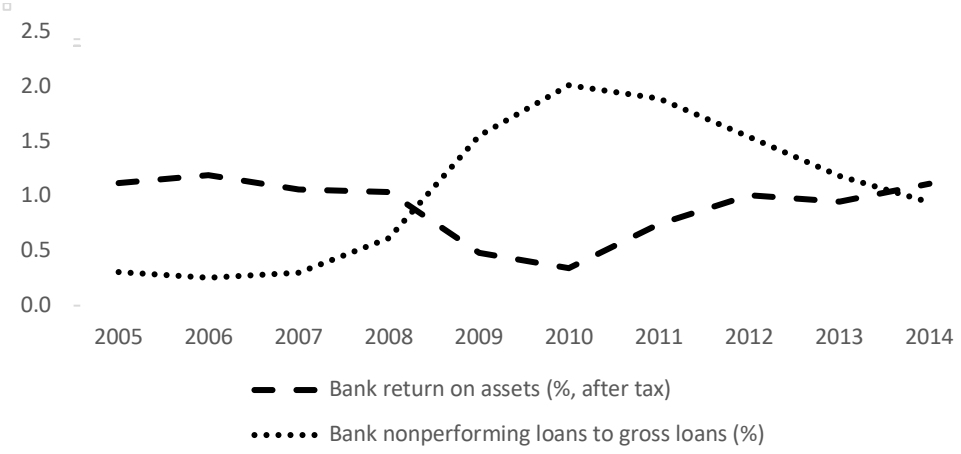


Figure 2- 6 Profitability and Asset Quality of Banks in New Zealand

Source: Global Financial Development Database (2014), Reserve Bank of New Zealand, (2015)

Figure 2-6 displays the profitability and asset quality of the New Zealand banking sector from 2005 to 2014. Profitability and asset quality were both negatively affected by the 2008 GFC. The banks' non-performing loan ratio increased from 0.7% in 2007 to more than 2% in 2010 before gradually declining over the period of 2011 to 2014. The trend of non-performing loan ratios suggests that loan assets deteriorated during and after the GFC and started to recover in 2011. The ROA ratio fluctuated around 1% from 2005 to 2008, followed by a decrease to 0.3% in 2010. The ratio climbed back to 1% in 2012 and remained stable until 2014.

2.9 Overview of the Singapore Banking Industry

Along with the country's independence in 1965, Singapore started developing into one of the biggest global financial centres. Dr Alber Winsemium, an economic advisor, suggested at the time that Singapore could utilise its strategic time zone and bridge the gap between important financial markets. The Asian Dollar Market was established in 1968 and aimed to fill the gap between the US and European markets (Woo, 2017).

As of the end of 2016, 65% of the financial system's total assets come from the banking sector (Financial Stability Board, 2018), implying the dominant role of banks in Singapore. With Singapore becoming an international financial hub, the banking sector in the country has experienced rapid development. At the end of June in 2017, 128 commercial banks were operating in Singapore with

total assets of SG$ 2418 billion. Banks in Singapore engage in a comprehensive range of financial activities, including traditional bank activities, corporate finance, and fund management. There are two types of banks in Singapore; full banks and wholesale banks. According to the Monetary Authority of Singapore (MAS), full banks are permitted to conduct a broad range of personal and corporate banking businesses, while wholesale banks may not carry out Singapore Dollar retail banking activities (MAS, 2017). At the end of 2017, the four largest full banks are the Bank of Singapore, DBS Bank, the Oversea-Chinese Banking Corporation, and the United Overseas Bank.[3] All of the four banks are designated as domestically important banks (Financial Stability Board, 2017).

The Monetary Authority of Singapore (MAS) acts as the central bank of Singapore and conducts integrated supervision of financial services and financial stability surveillance. Currently, MAS is in the process of implementing the remaining Basel III standards. The domestic banking system was heavily regulated and protected until the late 1990s. Since 1971, foreign banks were restricted to the wholesale banking market, and international incorporated full licensed banks were limited to opening new branches and relocating. Locally banks were protected from external competition with restrictions on their foreign competitors. Under such circumstances, local banks developed rapidly and dominated the financial market. During the 1997 AFC, commercial banks that had adequate capital were not affected directly, however some still suffer from massive losses due default loans from companies which were affected by the crisis (Sufian and Abdul, 2007).

The recent 2008 GFC, however, was claimed to have caused Singapore's largest economic recession since independence, with a loss of 9% in economic value (BIS, 2011). Two government-operated enterprises, the Government Investment Corporation of Singapore and Temasek Holdings, were heavily exposed to US subprime assets and experienced massive losses during the GFC. Despite sharp economic downturns, Singaporean banks maintained adequate capital and liquidity levels and showed resilience during the crisis. As Heng (2011) indicated, prudential risk management allowed banks to weather the shocks well (MAS, 2012).

Figure 2-7 shows that the profitability and asset quality of Singaporean banks were not severely affected during the 2008 GFC. The ROA ratio fluctuated between 1 and 1.5% during the period of 2005 to 2014, and there was no sign of a sharp decline in the ROA ratio during the crisis. The non-performing loan ratio experienced an increase from 1.4% in 2008 to 2% in 2009. It decreased to the previous level of 1.41% in 2010. From 2011 to 2014, the non-performing loan ratio kept reducing to its lowest level of 0.76% in 2014, suggesting the asset quality in the banks were well managed after the 2008 GFC.

[3] The Far Eastern Bank was merged into the United Overseas Bank on the 1st October 2017.

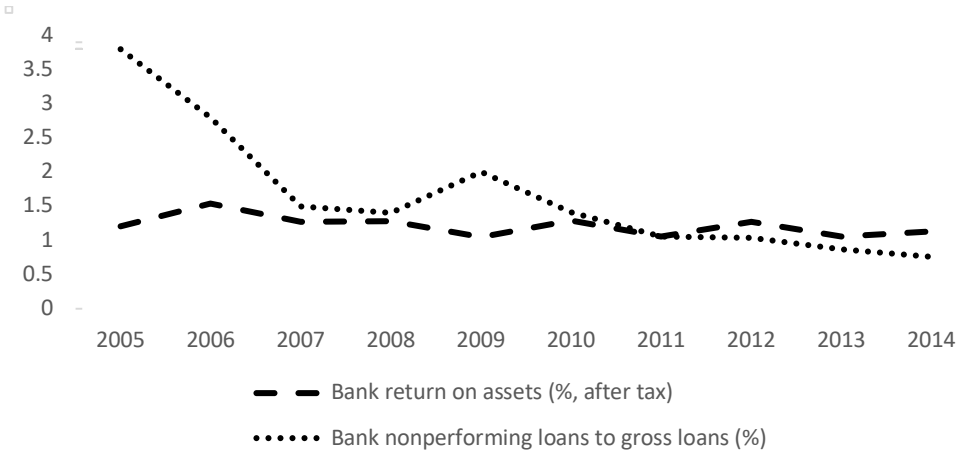


Figure 2- 7 Profitability and Asset Quality of Banks in Singapore

Source: Global Financial Development Database (2014).

2.10 Overview of the Thai Banking Industry

The Thai financial system plays a vital role in country's economy. At the end of 2015, 31 commercial banks accounted for almost half of the total assets of Thailand's financial institutions. Based on the Bank of Thailand's definition, commercial banks can be divided into commercial banks (universal banks), retail banks, foreign commercial bank subsidiaries, and foreign commercial bank branches (Bank of Thailand, 2018).

In the early 1990s, Thailand initiated deregulation and financial liberalisation. To encourage overseas capital flows into the domestic market, the Bangkok International Banking Facility (BIBF) was built in 1993 as an offshore financial market (Collignon, Pisani-Ferry, and Park, 2003). With rapid economic growth and low labour costs, Thailand attracted many foreign investors and enjoyed increased export levels. The heated economic growth and sizeable overseas capital inflow encouraged domestic banks to lend considerable funds to the real estate sector (Lai, 2000). In 1996, the growth of the domestic economy and net exports in Thailand began to slow. Local companies accumulated substantial bad debts and were not able to repay their loans.

Moreover, in the same year, Thailand stopped pegging the local currency to the US dollar. As a great number of companies declared bankruptcy, Thailand entered an economic crisis in 1997 (Dang-Thanh and Nguyen, 2012). Since then, the Thai banking industry has experienced several major structural changes and reforms. Firstly, the Bank of Thailand raised interest rates in response to the devaluation of the Thai Baht, causing lower revenues for the banking sector. Secondly, several solvent banks were nationalised, merged, or acquired by other banks. Thirdly, the banking sector was recapitalised by foreign investors after Thai authorities permitted foreign investors to hold more than 49% of bank shares (Sufian and Habibullah, 2010).

During the recent 2008 GFC, the Thai banking industry avoided massive direct impact due to little exposure and reliance on foreign assets. Under regulation and supervision by the Bank of Thailand, Thai banks were well-capitalised and held adequate liquidity (Bank of Thailand, 2011). The two indicators shown in Figure 2-8 confirm that the banking industry was not severely affected by the 2008 GFC. The banking industry's profitability was affected marginally, and the ROA ratio decreased from 1.34% in 2005 to 0.17% in 2007, which may have been a result of the global economic slowdown (Bank of Thailand, 2011). From 2007, the ROA ratio increased slowly to 1.46% in 2014. The asset quality of banks, however, improved over the period of 2005 to 2014.

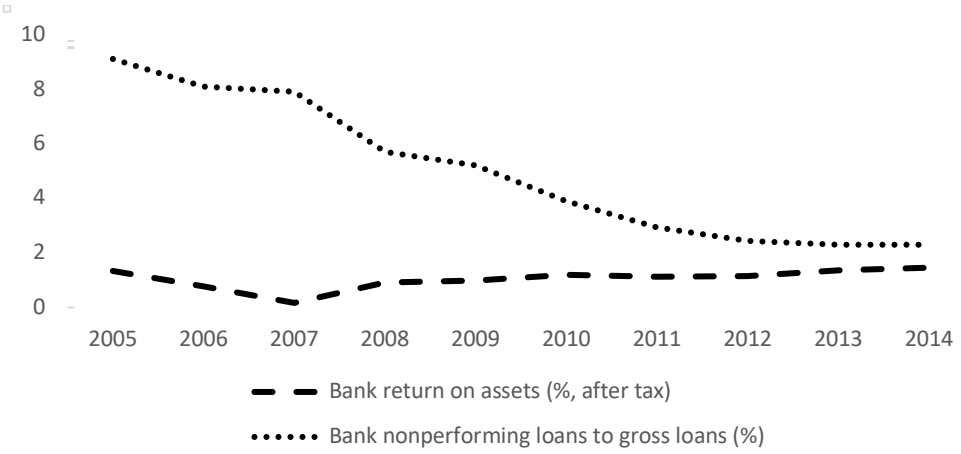


Figure 2- 8 Profitability and Asset Quality of Banks in Thailand

Source: Global Financial Development Database (2014).

2.11 Conclusion

Banks in the Asia-Pacific region share common characteristics. First, all of the banking industries have gone through financial deregulations and reforms during the 1970s to 1990s, followed by rapid economic and financial development. Second, due to experience gained from previous domestic and regional financial crises, banking sectors in this region were currently under relatively conservative regulation and supervision. Third, since the financial crises in the 1980s and 1990s, governments in the Asia-Pacific region have adopted restructuring schemes to recover their financial systems until the early 2000s. Nationalisation was part of these restructuring programmes. In short, in the Asia-Pacific region, state ownership still plays a vital role in the banking industry. Fourth, banking industries in the region have sheltered themselves from the recent 2008 GFC quite well; this can be partly attributed to conservative regulation, supervision and government interventions. Despite similarities, the banking industries in the region exhibit different levels of performance. For example, Australia, Hong Kong, New Zealand, and Singapore were more affected by the 2008 GFC than other countries. Moreover, bank profitability in developing countries is generally higher than that of

developed countries. All these similarities and dissimilarities make it valuable to assess the relationship between bank regulation, supervision, state ownership and bank efficiency in this region.

Chapter 3

Literature Review

3.1 Introduction

Having briefly introduced the banking industries in the Asia-Pacific region in Chapter Two, this chapter reviews the related literature on bank efficiency, regulation and supervision, and state ownership. Section 3.2 introduces the background of bank efficiency measurement, different types of efficiency, and previous studies on the inclusion of off-balance sheet activities in efficiency measurements. Section 3.3 discusses the literature on bank efficiency estimation in the Asia-Pacific region. Section 3.4 reviews previous studies on the relationship between bank regulation and supervision, state ownership, and efficiency. Section 3.5 concludes with a summary of the main findings of previous studies.

3.2 Introduction of Efficiency Measurement

3.2.1 Background

Efficiency is a commonly used concept to describe a firm's performance. The basic idea of efficiency measurement is to compare observed production to optimal production, which lies on the production frontier. From different measurement perspectives, efficiency can be measured by comparing observed outputs to maximum potential outputs, using the same amount of inputs. Or it can be measured by comparing observed inputs to minimum potential inputs to produce the same level of outputs (Fried et al., 2008).

Optimal production is also known as production on the best practice frontier. As the real frontier is not observable, it is necessary to estimate an empirical approximation of the frontier before obtaining relative efficiencies of individual firms. There are two approaches used to conduct approximation of frontier and efficiency estimation: the parametric approach (also known as the econometric technique) and the nonparametric approach (also known as the mathematical programming technique). Both approaches are benchmarking methods, which exploit the distance function between observed production and the production frontier. Among the various techniques stemming from these two approaches, the two most popular approaches employed in previous research are Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA).

3.2.2 Types of Efficiency Measurements

The feasible maximum outputs or minimum inputs under the given technology set is also referred to as the frontier of the technology set (Bogetoft and Otto, 2010). Efficiencies measured relative to this frontier are called technical efficiency. Koopmans (1952, p. 60) provides an official definition of technical efficiency:

> *"A producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Thus, a technically inefficient producer could produce the same outputs with less of at least one input, or could use the same inputs to produce more of at least one output."*

Farrell (1957) first introduced input-orientated and output-orientated technical efficiency to specify measurement perspectives which can be applied to different industries and businesses. An output-orientated technical efficiency is a radial expansion in the combination of the outputs with given inputs. Similarly, an input-orientated technical efficiency can be measured as the radial reduction in the inputs with given outputs.

Additionally, overall technical efficiency is measured under the assumption of constant returns to scale in the production process. Pure technical efficiency is estimated using the assumption of various returns to scale. When overall technical efficiency is not equal to pure technical efficiency, the firm is not scale efficient, suggesting that the firm is operating in either increasing or decreasing returns to scale situations (Coelli et al., 2005).

Using more information about the production process, three additional types of efficiency can be measured. When assuming the firm's objective is cost minimisation, cost efficiency can be obtained by comparing observed costs to potential minimal costs used to produce the same bundle of outputs given input prices. Cost efficiency can be decomposed into overall technical efficiency and input allocative efficiency. Input allocative efficiency is used to describe how well a firm chooses the best combination of inputs to produce the same amount of outputs with minimum costs. Assuming a firm's objective is profit maximisation, profit efficiency can be measured by comparing a firm's observed profit with the maximum potential profit given the input and output prices (Coelli et al., 2005; Vu and Turnell, 2011). Profit efficiency can be decomposed into overall technical efficiency, input allocative efficiency, and output allocative efficiency. In addition, X-efficiency is sometimes used to represent all technical efficiencies and allocative efficiencies and can be used to measure a manager's ability to control costs and profits (Mester, 1994).

When considering dynamic changes in efficiency, the Malmquist index is the most popular measurement. The Malmquist index can be used to measure how much a firm's efficiency can

improve from one period to the next. There are two causes of performance changes: technological progress in the whole industry and individual improvement, which differentiates one firm from other firms (Bogetoft and Otto, 2010).

When estimating efficiencies for firms operating in different regions or countries, most of the previous studies have used pool data to estimate a common frontier or meta-frontier and then estimate a firm's efficiently relative to the meta-frontier. However, Battese and Rao (2002) argue that the meta-frontier is not accessible for firms from all of the countries due to production technology limitations. For example, firms from some countries may have limited capital, labour, or lower production technology compared to other countries. Battese et al. (2004) and O'Donnell et al. (2008) estimate efficiency relative to the group/country frontier and meta-frontier and calculate the gaps between country-frontiers and meta-frontier. These gaps are defined as technology gap ratios and are used to describe the distance from one country's technology set to the region's technology set of the whole sample area.[4]

3.2.3 The Inclusion of Off-balance Sheet Activities in Efficiency Estimation

When selecting inputs and outputs for bank efficiency estimations, Berger and Humphery (1997) suggest that there are two major approaches: the production approach and the intermediation approach. The production approach regards banks as normal production entities which use labour and capital to produce loans, deposits and other earning assets. In the intermediation approach, banks function as financial intermediaries and use deposits and labour to create loans and other earning assets (Sealey and Lindley, 1977).

Considering the expansion in banks' business scope during production, researchers now recognise the importance of incorporating off-balance sheet (OBS) activities in bank efficiency estimations. While most studies directly include OBS activities into efficiency estimations (see for example, Drake, 2001; Drake and Hall, 2003, Sturm and Williams, 2005; Kirwood and Nahm , 2006; Fu and Heffernan, 2007; Hadad et al., 2011; Radic, Fiordelisi, and Girardone, 2012; Sufian et al., 2012), only limited numbers of studies provide justification for the inclusion of OBS activities in efficiency estimations (Rogers, 1998; Mester, 1996; Clark and Siem, 2002; Lieu et al., 2005; Pariouras, 2008; Lozano-Vivas and Pasioura, 2010; Lozano-Vivas and Pasiouras, 2014).

Roger (1998) measures the efficiency of more than 10,000 commercial banks (including branches) in the US, over the period of 1991 to 1995. Their results indicate that cost and profit efficiencies of

[4] This is for out-orientated technical efficiency. Under the input-orientated assumption, the technology gap ratio describes the minimum input a firm can use to produce the same output using technology in the whole sample area.

commercial banks would both be underestimated when OBS activities are omitted. Similarly, Clark and Siems (2002) examine the impact of including OBS activities on efficiency measurements in the US banking industry from 1992 to 1997. They conclude that OBS activities are useful for explaining variations in banks' costs and profits. Even though the cost efficiency is higher when including OBS activities, their results demonstrate little change in profit efficiency measurement. Using the SFA approach, Lieu, Yeh, and Chiu (2005) measure cost efficiency of the Taiwanese banking industry from 1998 to 2001. They conclude that omitting OBS activities would lead to underestimating cost efficiency by 55%. For the Greek banking industry, during the period from 2000 to 2004, Pasiouras (2008) find that bank cost efficiencies are not significantly affected by omitting OBS activities.

Using large samples from multiple banking industries around the world, Lozano-Vivas and Pasiouras (2010, 2014) examine the impact of including OBS activities on cost efficiency, profit efficiency, and Malmquist productivities measurements. They find mixed results. Lozano-Vivas and Pasiouras (2010) explore cost and profit efficiency for 87 countries from 1999 to 2006 and find that cost efficiency would be higher when considering OBS activities, while the results for profit efficiency are mixed. Using data from 84 countries, from 1999 to 2006, Lozano-Vivas and Pasiouras (2014) estimate the Malmquist cost productivity and bank profit productivity. They find that bank profit productivity would be higher when incorporating OBS activities, while cost productivity is not significantly affected. Moreover, their results suggest that the exclusion of OBS activities would jeopardise regression results when examining the relationship between environmental factors and bank performance.

3.3 Literature Review on Bank Performance in the Asia-Pacific Region

After Sherman and Gold (1985) first measured the efficiency of commercial bank branches in the US, studies on bank efficiency have proliferated in different countries over different periods of time. However, most of the early research focuses on the US banking industry (see for example, Ferrier and Lovell, 1990; Humphrey, 1991; Beger and Humphrey, 1992; DeYoung, 1994) or European countries (see for example, Berg et al., 1992; 1995). With the development of financial industries in the Asia-Pacific region, more scholars and researchers have begun to show an interest in measuring bank performance in this region. They provide empirical evidence for both single-countries and cross-country levels.

3.3.1 Bank Performance Measurement of Individual Countries

3.3.1.1 Australian Banking Industry

Since deregulation in 1997, most studies have sought identify how deregulation affects Australian bank performance. Sathye (2001) examines the technical efficiency and allocative efficiency of

Australian banks in 1996 using the DEA approach. Australian banks are found to have an average overall efficiency score[5] of 0.58 and an average technical efficiency score of 0.67, which are smaller compared to previous studies in European and US banking industries. Sathye (2001)'s results suggest that inefficiency in Australian banks is mostly due to wasted inputs rather than input allocation. Using a sample from a more extended period (from 1995 – 1999), Neal (2004) estimates the X-efficiency of Australian banks using the DEA approach. The results imply that average pure technical efficiency decreased from 1995 to 1997 before deregulation, and increased in 1998 and 1999 after deregulation. Similarly, Sturm and Williams (2005) provide empirical evidence of increased efficiency, supporting the positive impact of deregulation in the Australian banking industry from 1988 to 2001.

Focusing on the ten listed banks in Australia, Moradi-Motlagh and Saleh (2014) employ the bootstrap DEA approach to re-examine bank performance from 1997 to 2005. Their results indicate that Simar and Wilson (2007)'s bootstrap DEA approach can provide a more precise efficiency measurement than the previous DEA, SFA, and productivity index measurements. Furthermore, their results show that small banks' pure technical efficiency declined during the period after deregulation, partly due to increasing competition.

3.3.1.2 The Chinese Banking Industry

There have been an increasing number of studies in the efficiency of Chinese banking industry since the economic reform in 1978. Most of these studies compare performances of different banks (and types of banks) and provide mixed results.

Using bank data from 1993 to 2000, Chen, Skully, and Brown (2005) find that the four largest state-owned banks and smaller banks are more efficient than the medium-sized banks. Despite the negative impact of the 1997 AFC, deregulation which began in 1995, was found to have improved the overall efficiency of Chinese banks. Similarly, Majid and Sufian (2008) examine the listed Chinese banks' efficiency, from 1997 to 2006, using the DEA Window Analysis approach. Their results indicate that larger banks have higher overall technical efficiency and pure technical efficiency compared to medium- and small-sized banks. However, medium-sized banks have shown greater scale efficiency. Using data from 1994 to 2007, Dong et al. (2014) find that the largest four state-owned banks are the most cost efficient, while city commercial banks are the least efficient. Wang et al. (2014) provide more recent evidence to show that the four largest banks are more efficient than joint-stock banks for most of the years, over the period of 2006 to 2011. More recently, Tan and Anchor (2017) and

[5] Efficiency scores are generally estimated within a range of 0 to 1. The closer the efficiency score gets to 1, the more efficient the firm is. The closer the efficiency score gets to 0, the more inefficient the firm is (see Chapter 4 for further details).

Tan and Floros (2018) find that the largest four state-owned banks are more technically efficient than other types of banks, from 2003 to 2013.

In contrast, Ariff and Can (2008)'s measure of Chinese bank efficiency from 1995 to 2004, find that joint-stock banks perform better than state-owned banks, with both higher cost and profit efficiency. Sufian and Habibullah (2009) find that joint-stock banks are most technically efficient from 2000 to 2005. Yin and Yang (2013) examine the technical efficiency of Chinese banks from 1999 to 2010 and suggest that Chinese bank efficiency has improved since China joined the WTO. Their results also suggest that joint-stock banks are the most efficient, while the four largest state-owned banks are the least efficient. Dividing state-owned banks into two different groups, Berger, Hasan, and Zhou (2009) find that the four largest state-owned banks are the least profit efficient, while other state-owned banks are the most cost efficient.

3.3.1.3 Hong Kong Banking Industry

Studies on the Hong Kong banking industry have mostly investigated the impact of environmental factors on bank performance. Kwan (2006) examines the cost efficiency of Hong Kong commercial banks, from 1992 to 1999. The author finds that average efficiency increases over the study period despite a slight decrease after the 1997 AFC. This indicates a trend of technological improvement in Hong Kong. However, Drake, Hall, and Simper (2006) find that banks in Hong Kong show a modest deterioration in their performance from 1995 to 2001, due mainly to protection measures (restricted entry for foreign competitors and interest rate controls). The most recent study, Hall, Kenjegalieva, and Simper (2012), shows that the Hong Kong banking industry exhibits an upward trend in technical efficiency from 2000 to 2006. Furthermore, private housing rent and exports are negatively related to bank efficiency, while private consumption is positively associated with bank efficiency in Hong Kong.

3.3.1.4 Indonesian Banking Industry

Limited studies have focused on Indonesian bank performance. Confirming a negative impact from the 1997 AFC, Margono, Sharma, and Melvin II (2010) find that Indonesian cost efficiency decreases dramatically after the 1997 Asian Financial Crisis, from 0.8 before the crisis (1993-1997) to 0.53 after the crisis (1998-2000). Moreover, state-owned banks in Indonesia are found to be less cost efficient than other types of banks. The average cost efficiency of Indonesian banks is 0.7 from 1993 to 2000. More recently, Ariff (2011) employ both the DEA and the SFA approaches to measure Indonesian banks' cost and profit efficiency from 2004 to 2008. Average cost efficiency is higher than profit efficiency in the Indonesian banking industry. Additionally, their results of efficiency estimation indicate that average cost efficiency, overall technical efficiency, and allocative efficiency are 0.918,

0.979, and 0.939 over the study period, respectively. This suggest that cost inefficiency in banks is related to allocative inefficiency.

3.3.1.5 Japanese Banking Industry

Since the asset price bubble outburst, problem loans have been a persistent obstacle in the efficient operation of the Japanese banking industry. Most of the studies in the Japanese banking industry have tried to incorporate the impact of non-performing loans in bank efficiency measurements. Altunbas et al. (2000) include loan loss provisions as one of the production inputs when estimating scale efficiency and X-efficiency of Japanese banks, from 1993 to 1996. Their results indicate that average X-efficiency of Japanese banks is higher than scale efficiency. Furthermore, scale efficiency is more sensitive to the inclusion of risk and quality factors. Drake and Hall (2003) include problem loans as an uncontrollable output when estimating Japanese bank technical and scale efficiency in 1997. Their results indicate that larger banks are more efficient than their smaller counterparts. Moreover, when controlling risk and problem loans, bank efficiency increases in both technical efficiency and scale efficiency, particularly for smaller regional banks.

Alternatively, Barros et al. (2012) incorporate non-performing loans as an undesirable output when measuring the technical efficiency of Japanese banks from 2000 to 2007. Their results indicate that non-performing loans still significantly affect bank performance and that Japanese banks need to be restructured and consolidated in a more comprehensive reform to improve bank efficiency. Similarly, Mamatzakis et al. (2016) investigate the technical efficiency of Japanese banks over the period of 2000 to 2012 after modifying problem loans in the banks. They find that the efficiency of Japanese banks decreases from 2000 to 2012, and show no evidence of technical progress.

3.3.1.6 Singapore Banking Industry

Due to strong development over the last few decades, Singaporean banks operate with a high level of efficiency. Chu and Lim (1998) use the DEA approach to measure the cost and profit efficiency of six listed Singapore commercial banks over the period of 1992 to 1996. The average profit efficiency (0.83) was significantly lower than the average cost efficiency (0.95). However, the Singaporean bank profit efficiency scores are higher than those in the US (0.64) and Spain (0.72). They find that profit efficiency changes would affect share prices of the listed banks rather than cost efficiencies, indicating that shareholders are more sensitive to bank profits. Pure technical efficiency and scale efficiency are close to each other, with an average pure technical efficiency of 0.978 and an average scale efficiency of 0.974. Sufian and Abdulmajid (2007) investigate the technical efficiency and scale efficiency of Singaporean banks from 1998 to 2004 using the DEA approach. The bank overall technical efficiency increases from 0.92 to 0.95, suggesting excellent performance after mergers in

2001. The average pure technical efficiency is higher than the scale efficiency for banks in Singapore over the study period.

3.3.1.7 New Zealand Banking Industry

The New Zealand banking industry has attracted limited attention from researchers in bank efficiency estimations. Tripe (2003) employs the DEA approach to investigate efficiency improvements in the New Zealand banking industry from 1996 to 2002. The empirical evidence shows that bank efficiency increases over the study period. This is attributed to technical progress and lower interest rates. To capture the impact of the 2008 GFC, Adgei-Frimpong et al. (2014) investigate efficiency and productivity changes over the period 2007 to 2011 and find that the average overall efficiency, pure technical efficiency, and scale efficiency are 0.955, 0.985, and 0.969 for New Zealand banks, indicating high efficiency in the banking industry. Scale inefficiency is found to be the main contributor to overall inefficiency. Despite variations in efficiencies over the 5-year period, the New Zealand banking industry experienced a downward trend from 2007 to 2011.

Lu et al. (2018) employ stochastic frontier analysis to investigate bank efficiency in New Zealand over the period of 2002 to 2011. Average cost efficiency scores range from 0.833 to 0.963, and average profit efficiency scores range from 0.547 to 0.719. Larger banks in New Zealand tend to exhibit higher cost efficiency as well as higher profit efficiency than smaller banks.

3.3.1.8 Thailand Banking Industry

Using the 1997 AFC as a landmark for Thai banking industry development, the literature in the Thai banking industry can be divided into three types. The first type estimates bank efficiency under financial liberalisation and deregulation before 1997 (Leightner and Lovell, 1998; Williams and Intarachote, 2002); the second type measures bank performance and economic recovery after 1997 (Sufian and Habibullah, 2010); and the last one compares pre- and post-crisis bank efficiency (Chunhachinda and Li, 2010).

Leightner and Lovell (1998) construct Malmquist growth and productivity indexes for Thai banks from 1989 to 1994 and find that the Thai banking industry developed rapidly in production and total factor productivity during the study period. Employing the SFA approach, Williams and Intarachote (2002) estimate the efficiency of Thai banks after financial liberalisation (over the period of 1990 to 1997). Their results show that efficiency decreased at an increasing rate over the entire study period. Despite rapid economic and financial development in Thailand before the 1997 AFC, their findings suggest that the expansion of the banking industry after financial liberalisation increased financial fragility.

Considering the banking industry after the 1997 AFC, Sufian and Habibullah (2010) use the DEA approach to estimate bank efficiency in Thailand from 1999 to 2008. They find that domestic banks are more efficient than foreign banks throughout this period. Additionally, the decomposition of technical efficiency indicates that scale inefficiency is the main source of overall technical inefficiency in the Thai banking industry.

Using a more extended time frame, Chunhachinda and Li (2010) assess the profit and cost efficiency of Thai commercial banks from 1990 to 2008. They use both the SFA and DEA approaches. Their results indicate that bank efficiency during the pre-crisis period is lower than during the post-crisis period (2001-2008), suggesting recovery and development in the Thai banking sector.

3.3.2 Cross-country Bank Performance Measurement in the Asia-Pacific Region

There are many cross-country studies of bank efficiency. Even though one or some of the countries in the Asia-Pacific region have been considered in previous work, only a few studies (Sathye, 2005; Fu, Lin, and Molyneux, 2014; Lee, Hsieh, and Yang, 2014) have focused on bank efficiency in the Asia-Pacific region and estimate bank efficiency relative to the regional frontier of this region.

Laeven (1999) examines the efficiency of banking industries in East Asia (Indonesia, Korea, Malaysia, the Philippines, and Thailand) over the period of 1992-1996. The author uses the DEA approach. The estimated efficiency scores indicate that banks in Indonesia, the Philippines, and Thailand experienced an increase in the efficiency, while bank efficiency in Korea and Malaysia did not change during this period. Furthermore, the study finds that state-owned and foreign banks in the East Asia took less risks than other types of banks (that is, family-owned, company-owned, widely-owned banks), before the 1997 AFC.

Considering Asian developing countries, Gardener, Molyneux, and Nguyen-Linh (2011) investigate the efficiency of commercial banks in Indonesia, Malaysia, the Philippines, Thailand, and Vietnam from 1998 to 2004. Their results indicate that state-owned banks have better performance than other types of banks after the 1997 AFC. However, average bank efficiency decreased in these Asian developing countries during this period.

For banks in Australia and New Zealand, Avkiran (2009) uses a new four-stage DEA approach to examine bank efficiency from 1996 to 2003. The empirical results indicate that Australian banks are less efficient than those in New Zealand over this period. Moreover, the interest rate is found to be negatively associated with bank efficiency in both countries.

Ioannidis, Molyneux, and Pasiouras (2008) examine cost and profit efficiency for 260 commercial banks in 19 countries in Asia (including China, Hong Kong, Indonesia, Japan, Singapore, and Thailand),

and Latin America from 2000 to 2006. Their empirical results show that the average cost efficiency of Asian banks is higher than banks in Latin America, Furthermore, cost efficiency of Asia banks exhibit a stable trend over the study period ranging from 0.9293 in 2001 to 0.9359 in 2004). The average profit efficiency shows an increasing trend from 0.7297 in 2000 to 0.7737 in 2006.

Considering the 2008 GFC, Wu et al. (2016) apply the DEA model in the banking industry of ASEAN[6] countries to estimate revenue efficiency from 2008 to 2013. After decomposing revenue efficiency into managerial efficiency and profitability efficiency, they find that the Singaporean banking sector exhibits higher overall profitability efficiencies, while banking sectors in Malaysia and the Philippines have the highest managerial efficiency. Overall bank efficiency, managerial efficiency, and profitability efficiency of the ASEAN banks show downward trends after the crisis.

Lin et al. (2016) investigate the relationship between ownership structure changes and bank cost efficiency in Asian developing countries from 2003 to 2012. Their results indicate that the average cost efficiency of Chinese banks is the highest (0.881), followed by the Hong Kong banking industry (0.86), Indonesia (0.856), Thailand (0.763), and Singapore (0.763). Moreover, they conclude that banks with foreign ownership can improve bank efficiency when there is a high level of financial freedom in the country. An increase in state ownership can improve bank efficiency only when there is a high level of financial freedom (after the 2008 GFC).

Using information from 715 banks from 95 countries in 2003, Pasiouras (2008) discovers that the banking industry in the Asia-Pacific region (except Australia) has higher efficiency than other areas around the world. More specifically, the average overall technical efficiency, pure technical efficiency, and scale efficiency of Asia-Pacific banks are 0.7567, 0.7745, and 0.9766, against average world values of 0.6680, 0.7080, and 0.9450, respectively. The Australian banking industry is examined separately and has overall technical efficiency, pure technical efficiency, and scale efficiencies of 0.5983, 0.7638, and 0.8246, respectively, indicating that Australian banks are scale inefficient in their production compared to other regions. Pasiouras et al. (2009)'s study of bank efficiency in 74 countries from 2000 to 2004, shows that the average cost and profit efficiency of Asia Pacific countries are 0.8757 and 0.8201. Moreover, Australian banks have an average cost efficiency of 0.9178 and profit efficiency of 0.8201, showing better performance than other countries in the Asia-Pacific region. In Barth et al. (2013)'s study of 73 banking industries around the world (over the period of 1999 to 2007), the average technical efficiencies for banks in Australia, Hong Kong, Japan, New Zealand, Singapore, and Thailand are 0.81, 0.82, 0.85, 0.75, 0.86, and 0.78, respectively,

[6] ASEAN: Association of Southeast Asian Nations.

suggesting that Japanese and Singapore banks are more efficient, while New Zealand and Thai banks are less efficient before the 2008 global financial crisis.

Sathye (2005) measures overall technical efficiency, pure technical efficiency, and scale efficiency for large banks in the Asia-Pacific region in 2002. Compared to other countries, Australian, New Zealand, and Indonesian banks are most efficient in terms of the three efficiency measurements. In contrast, Chinese, Hong Kong, and Singaporean banks are the least efficient in 2002. After incorporating environmental factors (that is, population density, per capita income, equity to total assets, intermediation ratio) into bank efficiency measurements, the average technical efficiency is much larger, suggesting that neglecting environmental factors in efficiency measurements can be misleading.

Lee, Hsieh, and Yang (2014) measure bank performance in 29 Asia-Pacific countries using financial ratios; for example, return on average asset (ROA), return on average equity (ROE), the standard deviation of ROA and the standard deviation of ROE from 1995 to 2009. Their results indicate that revenue diversification would improve bank performance. However, bank supervision would weaken the positive relationship between revenue diversification and bank performance.

Focusing on 14 Asia-Pacific countries, Fu, Lin, and Molyneux (2014) examine the relationship between cost and profit efficiency and shareholder values from 2003 to 2010. Their results indicate that both profit and cost efficiency are positively related to shareholder values. For individual countries, they find that both cost and profit efficiency in Hong Kong, Japan, and Thai banking industries have increased. The profit efficiency of banks in Australia, China, Indonesia, and Singapore increased, while cost efficiency decreased over the period of 2003 to 2010.

3.4 Literature on Bank Regulation and Supervision

3.4.1 Capital Regulation in the Banking Industry

As one of the primary regulatory tools and first pillar of Basel Accord II, higher capital regulation exerts a direct influence on bank efficiency. According to the agency cost hypothesis, there are two opposing views on the impact of capital requirement on bank performance. On the one hand, a higher capital ratio can limit shareholder risk-taking at the expenses of debt holders. Therefore, stricter capital requirements are positively related to bank performance (Jensen and Meckling, 1976, Boudriga, Taktak, and Jellouli, 2009). On the other hand, higher capital ratios might reduce managers' incentives to maintain good performance since there is less pressure from debt holders. In this case, stricter capital regulation is negatively related to bank performance (Grossman and Hart, 1982; Pessarossi and Weill, 2015).

Previous studies have provided ambiguous empirical results on the impact of capital requirement on efficiency in the banking industry. Santomero and Watson (1977) suggest that tighter capital regulation results in a decrease in credit offers and lead to less productive investments in the whole economy. Berger and Bonaccorsi di Patti (2006) examine the capital structure of the banking industry in the US between 1990 and 1995. Their results indicate that a lower capital ratio or higher leverage ratio is linked to higher profit efficiency. Acharya (2001), Brana and Lahet (2009) find that capital adequacy regulation could increase systemic risk in the banking industry and even trigger financial crises. They suggest that the capital adequacy ratio should be designed based on both the risks of individual banks as well as systemic risk in the banking sector.

In contrast to the studies above, Fare, Grosskopf, and Weber (2004) examine the effect of risk-based capital requirement on profit efficiency in the US banking industry in 1990, 1992, and 1994 using the DEA approach. After decomposing profit efficiency into technical efficiency and allocative efficiency, their results suggest that capital constraints have a positive impact on allocative and profit efficiency, and do not affect the technical efficiency of banks. Fiordelisi et al. (2011) investigate the relationship between bank efficiency and capital ratio using the Granger-causality test in the GMM dynamic panel framework. They focus on the European banking industry from 1995 to 2007. Their results indicate that well-capitalised banks operate with higher levels of efficiency.

Considering the impact of the 1997 AFC, Banker, Chang, and Lee (2010) use empirical evidence from the Korean banking industry over the period of 1995 to 2005. They suggest that the positive effects of capital adequacy ratio on bank efficiency are stronger during the 1997 AFC. However, the positive relationship was found to be weaker in the post-crisis period. More recently, Berger and Bouwman (2013) examine the US banking industry over the period of 1984 to 2010 and discuss the relationship between capital requirements and bank profitability. Their findings suggest that higher capital ratios help banks to survive unfavourable conditions and boot their profitability and market shares.

3.4.2 Official Supervision Power and Market Discipline in the Banking Industry

The second and third pillars of Basel II are official supervision and regulation rules, which promote market discipline in the banking industry (hereafter referred to as market discipline). Official supervision power allows regulatory authorities to take action against managers, shareholders, and auditors when it is necessary. Market discipline describes the degree to which banks are required to provide accurate and adequate information to the public.

Advocates of official supervision believe that compared to private agents, empowered official supervisor have more incentives and ability to monitor banks. Therefore, a powerful supervisor can improve corporate governance in the banking industry (Stigler, 1971), limit corruption in bank

lending, and enhance efficiency (Beck et al., 2006). However, opponents of official supervision believe that governments are self-interested (Hamilton et al., 1788; Stigler, 1975; Boot and Thakor, 1993) and that official supervisors are likely to abuse their supervisory power for political objectives (Harbet et al., 2003). Thus, researchers suggest that market discipline provides a better solution (Hay and Shleifer, 1998; Beck et al., 2006).

Beck et al. (2006) investigate the relationship between supervisory strategies and corporate financing obstacles in 37 countries. They find that higher official supervision power is related to less integrity in bank lending. In terms of the German banking industry, Dam and Koetter (2012) find that certain supervisory policies can reduce the probability of government bailouts while other policies increase this probability. Rezende and Wu (2014) use the information from US commercial banks to examine the impact of supervision (measured as the minimum frequency of examinations of commercial banks) on bank performance. Their results indicate that more frequent inspections can reduce loan loss and positively affect commercial banks' profitability. Likewise, Hurtle et al., (2016) examine supervision in US bank holding companies and find that big bank holding companies tend to keep less risky loan portfolios and engage in more conservative loan loss reserve practices when they face more supervisory pressure, particularly in comparison to smaller bank holding companies.

Some studies have examined the two pillars and found opposing effects on banking industries. Reviewing the impact of market discipline on bank performance in Japan, Bremer and Pettway (2002) find that official supervisors protect weak banks by not releasing negative bank information after asset price bubble collapses, whereas markets penalise banks when bank credit ratings are downgraded. Using data from 107 countries over the period of 1999-2000, Barth et al. (2007) also conclude that strengthening official supervision power would increase overhead costs and lead to increasing corruption in banking. In contrast, regulatory policy which requires more information disclosure can reduce overhead costs as well as lending corruption.

Regarding the effects of information disclosure, Ostberg (2006) suggest that disclosing information can increase a firm's market value. Moreover, banks tend to refuse full information disclosure when the main shareholders want to benefit from investment returns. However, Chen and Hasan (2006) note that greater information transparency is likely to boost the probability of bank runs unless it is evident in the disclosed information that the risk is idiosyncratic rather than systemic.

3.4.3 Activity Restrictions in the Banking Industry

Activity restrictions are restrictions on non-bank activities (for example, real estate investment, insurance underwriting and selling, securities brokering and dealing, and all aspects of mutual fund

industries) imposed by regulatory authorities. Theories provide mixed arguments about whether banks should be allowed to participate in these sorts of activities.

On the one hand, banks are able to exploit informational economies (Benston, 1994; Rajan, 1998), utilise economies of scale and scope (Claessens and Klingebiel, 2001), and increase their franchise value (Pasiouras, 2008) by engaging in both traditional banking activities and non-bank activities. Therefore, regulation, which restricts non-bank activities could constrain the optimal business model and increase transaction costs (Bhattacharya et al., 1998). On the other hand, banks engaging in various non-bank activities could become "too big to discipline" (Laeven and Levine, 2007) for both regulatory authorities and private sectors. In addition, conflicts of interest and information asymmetry between banks and consumers may lead banks to use information for their benefit (Kroszner, 1998) and increase moral hazard and risk-taking (Boyd et al., 1998).

Empirically, Lozano-Vivas and Pasiouras (2010) find that more activity restrictions are related to higher profit efficiency. Their study examines 752 listed banks from 1999 to 2006. Furthermore, Delis and Staikouras (2011) note the positive impact of activity restrictions on the banking industry through reducing risks and non-performing loans in the banking industry. In contrast, Demirguc-Kunt et al. (2004) find that tighter regulations on bank activities would increase financial intermediation costs. Similarly, Barth et al. (1998, 2001) identify a negative impact on bank efficiency from tighter activity restrictions. However, Barth et al. (1998) did not find a reliable and direct link between activity restrictions and bank efficiency. Pasiouras (2008) find that activity restrictions are not significantly related to the overall technical efficiency of commercial banks in 95 countries.

Hossain et al. (2013) find that activity restrictions affect bank performance differently during normal times and crisis in the Asia-Pacific region. Also, more activity restrictions can help reduce the shareholder loss during the crisis, while those restrictions have a negative impact during normal times.

3.4.4 State Ownership in the Banking Industry

Most previous studies provide empirical evidence which supports the "political view" of state ownership and argue that state ownership is related to less development in the banking industry (Barth et al., 2001; La Porta et al., 2002); less profitability (Micco et al., 2007; Cornett et al., 2010; Lin and Zhang, 2009); lower profits and cost efficiency (Berger et al., 2005; Bonin et al., 2005; Perera et al., 2007; Margono et al., 2010). Nonetheless, a few studies find that state-owned banks are more efficient (Gardener et al., 2011; Wang et al., 2014; Dong et al., 2014; Berger et al., 2009) than other types of banks and are related to higher stockholder value (Hossain et al., 2013). Other studies (Barry

et al., 2008), however, find no significant difference between state-owned banks and privately-owned banks.

La Porta et al. (2002) create a database of state ownership of banks using data from the ten largest banks in 92 countries over the period of 1995 and 1970. They find that state ownership in the banking industry tends to be higher in countries with lower incomes, less developed financial systems, inefficient governments, and weak property rights. Moreover, higher state ownership is found to be associated with lower financial development and productivity. For the Argentina banking industry, Berger et al. (2005) suggest that state-owned banks are less profit efficient (measured as return on assets) and less cost efficient (measured as costs divided by assets) than other types of banks. Furthermore, the privatisation of banks is found to improve bank performance significantly in Argentina. Bonin, Hasan and Wachtel (2005) examine state ownership of large banks in transition countries (like Bulgaria, the Czech Republic, Croatia, Hungary, Poland, and Romania) and show that the state-owned banks are the least cost and profit efficient and that privatisation can improve bank efficiency. However, their results suggest that banks only gain efficiency in the early stage of privatisation. Using a large sample from 179 countries, Micco et al. (2007) find that state-owned banks are less profitable and have more personnel expenses in developing countries. Further, there is no significant difference between state-owned banks and other types of banks in developed countries. For developing Asian countries (for instance, Bangladesh, India, Pakistan, and Sri Lanka), Perera et al. (2007) find that state ownership is negatively related to cost efficiency (over the period of 1997 and 2004). Similarly, state-owned banks in Indonesia are found to be less efficient than other types of banks from 1993 to 2000 (Margono et al., 2010). Compared to foreign and private banks, Shaban and James (2018) also find state-owned banks are less profitable and more likely to be exposed to risks.

In contrast with the previous argument that state ownership impedes bank performance, Gardener, Molyneux, and Nguyen-Linh (2011) measure bank efficiency in Indonesia, Malaysia, the Philippines, Thailand, and Vietnam over the period of 1998 to 2004. They find that state-owned banks perform more efficiently than other types of banks. Hossain et al. (2013) also note that state ownership is a desirable government intervention mechanism used to reduce the negative impact on shareholder value in the Asia-Pacific banking industry. Empirical evidence has revealed better performance of the four largest state-owned banks (Wang et al., 2014; Dong et al. 2014; Tan and Anchor, 2017) than other banks in China. After estimating bank efficiency in Hong Kong, Indonesia, Korea, Malaysia, the Philippines, and Thailand, Barry et al. (2008) find that state-owned banks are not significantly different from privately-owned banks.

3.4.5 Empirical Evidence of Comprehensive Bank Regulation and Supervision in the Banking Industry

Barth et al.'s (2001, 2003, 2007, 2011) work on information on bank regulation, supervision, and state ownership has been used by numerous studies. Further research also provides cross-country evidence by examining the relationship in various aspects of bank regulation and supervision and bank efficiency. The empirical results of the relationships between regulation, supervision, state ownership, and bank efficiency vary in terms of countries, years, and efficiency types.

Using the net interest margin and overhead costs to measure bank efficiency (that is, lower net interest margins and overhead costs indicate higher efficiency in the banking industry), Barth et al. (2004) find that activity restrictions are negatively related to bank efficiency. While market discipline can significantly boost bank efficiency, capital regulation, and supervision power are not significantly related to bank performance. In addition, state ownership of the bank is negatively related to bank efficiency.

Pasiouras (2008a) examine the relationship between bank regulation, supervision, and bank technical efficiency for 715 banks from 95 countries in 2003. Their results indicate a positive correlation between capital adequacy regulation, official supervisory power, and market discipline with bank efficiency, supporting all three pillars of the Basel II. Furthermore, deposit insurance has no significant relationship with bank efficiency. They also find that both government and foreign ownership are associated with lower bank efficiency.

Pasiouras, Tanna, and Zopounidis (2009) find that bank regulations which empower official supervision and enhance market discipline are positively related to both profit and cost efficiency for 74 banking industries, over the period of 2000 to 2004. Moreover, capital regulation would increase cost efficiency while reducing profit efficiency during this period. In contrast, activity restrictions improve profit efficiency while increasing profit efficiency.

Lozano-Vivas and Pasiouras (2010) investigate cost and profit efficiency of 752 listed banks from 87 countries around the world, from 1999 to 2006. Their regression results indicate that capital regulation is positively related to bank cost efficiency while negatively associated with profit efficiency. However, supervisory power and activity restrictions are negatively associated with cost efficiency and positively related to profit efficiency. Market discipline has shown positive relationships with both cost and profit efficiency.

Chortareas et al. (2012) examine the relationship between bank regulation and supervision and bank efficiency in European countries over the period of 2000 to 2008. Their empirical results suggest that regulatory and supervisory policies, such as market discipline and activity restrictions, are likely to

reduce bank technical efficiency levels, while capital regulation and supervisory power are policies which can improve bank efficiency.

Barth et al. (2013) examine whether regulation and supervision improve or impede bank technical efficiency, in 72 countries from 1999 to 2007. Capital regulation is found to be positively related to bank efficiency, while activity restrictions are negatively related to bank efficiency. Moreover, official supervision power is only positively associated with bank industry when independent supervisory authorities are used. Further market discipline would improve bank efficiency when bank financial information is more transparent and widely available to the public.

In Luo, Tanna, and DeVita (2016)'s investigation of 2007 commercial banks from 140 countries over the period of 1999 to 2011, capital regulation, market discipline, and activity restrictions are found to be positively related to profit efficiency, while official supervisory power shows a negative relationship with profit efficiency.

Similar to Barth et al. (2004), Barth, Lee, and Lu (2015) use net interest margins and overhead costs to measure bank efficiency, from 1999 to 2011. Their empirical results reveal a negative relationship between capital regulation and bank efficiency. Moreover, capital regulation is positively related to non-performing loans. Incorporating the impact of the 2008 GFC, market discipline is positively related to bank development before the crisis. This positive relationship is weakened after the 2008 GFC. Official supervisory power tends to be negatively related to non-performing loans level in banks but can increase the possibility of banking crises.

Manlagnit (2015) estimate cost efficiency of commercial banks in the Philippines (over the period of 2001 to 2011), using the SFA approach. They examine the relationship between Basel II and bank performance. Their results suggest that capital regulation is positively related to bank efficiency, while supervisory power is negatively related to bank efficiency. Market discipline, however, is not related to bank performance in the country's banking industry.

Ayadi et al. (2016) examine the relationship between the adoption of international regulatory standards and bank technical efficiency using Simar and Wilson (2007)'s bootstrapping approach. They cover the period of 1999 to 2014 for 1146 banks across 75 countries. They consider activity restrictions, capital requirements, and market discipline in their study and find that regulation, which improves market discipline, is positively related to bank efficiency. However, the deposit insurance scheme and bank activity restrictions have a negative impact on bank efficiency.

Using regulation and supervision databases from 42 countries, Triki et al., (2017) examine the relationship between regulation and bank efficiency in Africa. Their results indicate that the effect of

bank regulation depends on bank size and bank risks. Among the regulatory indexes, capital stringency is positively related to larger banks and low-risk banks. Supervision and activity restriction is not significantly related to bank efficiency in Africa.

Varying from previous studies which use multiple regulatory and supervisory indexes, Gardener et al. (2011) create a comprehensive regulatory index to capture information related to activity restrictions, capital regulations, and market discipline in their study of East Asian banking industries. Their results suggest that bank regulation is negatively related to technical efficiency and positively related to allocative efficiency. Moreover, these relationships are not significant for state-owned banks, indicating that there is no significant relationship between regulation and state-owned bank performance.

Combining information with labour and business regulations, Psillaki and Mamatzakis (2017) investigate the relationship between credit regulation and bank performance for 10 Central and Eastern European banking industries over the period of 2004 to 2009. Their results support the public interest view of regulation and find that credit regulation is positively related to cost efficiency. Moreover, banks with higher capital ratios are more cost efficient.

3.5 Conclusion

Bank efficiency estimations of countries in the Asia-Pacific region have covered various periods. Earlier studies, such as Barth et al., (2001, 2004, 2007) use financial ratios to represent bank efficiency, while more recent studies tend to use the DEA approach or the SFA approach to measure bank performance. Despite increasing concerns about non-traditional banking activities, only a limited numbers of studies have discussed whether off-balance sheet (OBS) activities should be included in efficiency estimates. Except for Pasioura (2008), most of the studies emphasise the importance of considering OBS activities. However, results of how efficiency estimations change after including OBS are mixed.

Previous studies in banking regulation have focused mostly on capital regulation. Even though evidence has found that capital regulation can reduce credit offers and increase risks, most studies have found that capital regulation can benefit bank stability and improve bank performance. Most of the studies have shown that official supervision power and market discipline are significantly related to bank performance. However, whether these relationships are positive or negative remains ambiguous. While most studies suggest that activity restrictions could limit profit opportunities, there is evidence of the positive impact of activity restrictions on bank performance.

Most of the early studies on state ownership of banks support the “political view” of the government participation. A limited number of studies show that state-owned banks perform better. Others show

that state-owned bank performance is not different from other banks. External factors, such as financial crises, could alter the relationship between bank regulation, state ownership, and bank performance.

Chapter 4

Data and Methodology

4.1 Introduction

Chapter 4 describes the data and methodology employed in this study. Section 4.2 briefly discusses the efficiency type choices and the efficiency estimation approach used in this study. Section 4.3 describes the basic data envelopment analysis (DEA) approach and the double bootstrap DEA approach. Section 4.4 discusses both the input and output variables and the independent variables used in the regression models. Section 4.5 concludes with the analytical framework for this study.

4.2 Choice of Efficiency Estimation Approach and Regression Model

Bank efficiency has always been of great interest for researchers, policymakers, and other bank-related stakeholders. Previous studies have applied various measurements of bank performance and efficiency at regional, country and global levels.

As discussed in Section 3.2.2, there are different types of efficiency measurements. Compared to cost efficiency, revenue efficiency, and profit efficiency, technical efficiency measures banks' ability to convert inputs to outputs without considering input and output prices. Servin et al. (2012) indicate that certain financial institutions provide services and products at lower prices to benefit society and help the poor in developing countries. To exclude the impact of such factors on bank efficiency estimation, this study focuses on technical efficiency and aims to provide a fundamental measurement of the banking industry in the Asia-Pacific region. The other reason we choose to measure technical efficiency is that input and output price data are not available for a large number of banks in the sample countries.

Compared to the parametric approaches, such as stochastic frontier analysis, the non-parametric approach does not need to assume a functional form to define the shape of the production frontier. Given that the estimated efficiency of an individual bank depends partly on the frontier shape, the non-parametric approach is a better choice to avoid the assumption of dependency (Drake et al., 2006). Additionally, Fethi and Pasiouras (2010) point out that the non-parametric DEA approach works better with smaller-sized samples than other methods. Since our study involves estimating bank efficiencies in countries such as New Zealand which has a small number of banks, we chose the DEA approach in the bank efficiency estimation stage.

There is no consensus as to whether output-orientated or input-orientated approaches should be applied in the banking industry. Due to increasing competition in the financial markets, the amount

and prices of financial service and products are often decided by markets, not individual banks. Therefore, following previous studies in the banking industry (see for example, Drake et al., 2006; Barth et al., 2007, Chang et al., 2012; Chortareas, Ciraardone, and Ventouri, 2013), we employ the input-orientated DEA approach to estimate technical efficiency.

After obtaining efficiency scores for the sample banks, there are several common ways to examine the relationship between external environmental variables and the efficiencies. These are: (1) comparing bank efficiencies for groups with different environmental characteristics; (2) using environmental variables as one of the inputs or outputs for efficiency estimations; (3) conducting a second-stage regression approach (Coelli et al., 2005). The second-stage regression approach has been adopted by most of the recent literature.

According to Coelli et al. (2005), the main advantages of the second-stage regression approach are: (1) more than one environmental factor[7] can be included in the regression model; (2) both continuous and categorical variables can be included in the model; and (3) the approach can be used to examine if the impact of environmental variables on efficiency are significant. Simar and Wilson (2007) list at least 40 studies, which employ the second-stage regression approach in their research. The method includes efficiency estimations using the DEA approach, and the second-stage regression model is also called a two-stage DEA approach (Ray, 1991)

One problem associated with the second-stage regression approach is the choice of regression models (Ramalho, Ramalho, and Henriques, 2010).The three major concerns in choosing the regression models are: (1) the DEA efficiency estimators, which are used as the dependent variable, are bounded between zero and one; (2) the inputs and outputs used to estimate DEA efficiencies in the first stage are possibly correlated with environmental factors in the second stage; (3) efficiency estimators are serially correlated and dependent on each other. For example, changes in one firm's efficiency will affect the estimated frontier of the whole sample and therefore affect the firm efficiency on a whole (Simar and Wilson, 2007; Ramalho et al., 2010).

Most of the previous empirical studies have applied the Tobit regression model (see for example, Pasiouras, 2008; Sufian, 2009; Gardener et al., 2011; Ab-Rahim et al., 2012; Huang and Fu, 2013), which considers the range of the efficiency estimates between 0 and 1. A few other studies have adopted ordinary least square (OLS) regression (see for example, Fu and Hefferman, 2007; Lin et al., 2013; Gaganis et al., 2013) to estimate the impact of external environmental factors on bank

[7] Environmental factors are factors from outside of the banks.

efficiency. Simar and Wilson (2007) and Ramalho et al. (2010) argue that the Tobit and linear regressions do not provide the Data Generating Process (DGP) for the DEA efficiency scores.

To provide valid statistically interpretations of the regression results, Simar and Wilson (2007) describe DGP for the bootstrapping two-stage regression on DEA efficiency. They suggest that the double bootstrap DEA approach, which includes the bootstrap DEA approach in the first stage, and the bootstrap truncated regression model in the second state, can provide valid interpretations for both estimated efficiency and the relationship between external environmental factors and efficiency. In this study, we employ the double bootstrap DEA approach to estimate bank efficiency and examine the relationship between bank regulation, supervision, and ownership on bank efficiency.

4.3 Double Bootstrap DEA Approach in Banking Industry

4.3.1 Basic Data Envelopment Analysis (DEA) Approach

Farrell (1957) firstly proposes using the non-parametric frontier method to measure technical efficiency for firms using a single input to produce a single output. Based on Farrell (1957)'s idea, Charnes, Cooper, and Rhodes (1978) introduce the concept of "Data Envelopment Analysis" (DEA) for the first time. In Bogetoft and Otto (2010, p. 81)'s description, the DEA approach can be briefly defined as an approach which "*provides a mathematical programming method of estimating best practice production frontiers and evaluating the relative efficiency of different entities.*" These entities are referred to as Decision Making Units (DMUs). In our study, DMUs are the sample banks in the Asia-Pacific region.

Similar to conventional benefit/cost theory, the fundamental idea of efficiency measurement is to estimate a ratio of weighted outputs to weighted inputs for each DMU (Cook and Seiford, 2009). Charnes, Cooper and Rhodes (1978) use the DEA approach to measure firm efficiency, assuming all of the firms operate under a constant return to scale (CRS), which is also known as CCR or CRS model. Subsequently, Fare, Grosskopf, and Logan (1983) and Banker, Charnes, and Cooper (1984) propose the assumption of variable returns to scale (VRS) in the efficiency estimation, which is called the BCC or the VRS model (Coelli et al., 2005).

In efficiency estimations, banks operating on the production frontier are the best-practice banks with efficiency scores of one. Those which lie away from the frontier are considered to be inefficient, with efficiency scores less than one. Depending on the distance from the sample banks to the frontier, the DEA approach is employed to estimate relative efficiencies ranging from 0 to 1 (Cook and Seiford, 2009) for all of the individual banks. Since Charnes et al. (1978)'s study, there has been rapid development of the DEA approach. Based on different restrictions and assumptions, different

variations of DEA models, such as the free disposal hull (FDH) model, the slack-based DEA model, and the bootstrap model have been used (Coelli et al., 2005; Cook and Seiford, 2009).

Considering there are I banks in the sample data, each bank uses N inputs to produce M outputs. The input X_i for the i–th bank is a $N \times 1$ vector and the output Y_i is a $M \times 1$ vector for the i–th bank. Thus, the production set for bank i can be denoted as (X_i, Y_i). To measure the input-orientated technical efficiencies for bank i, the CCR model solves the following linear programming problem as in equation (4.1):

$$\begin{aligned} &min_{\theta,\lambda}\ \theta, \\ &s.t.\ \theta X_i - X\lambda \geq 0, \\ &-Y_i + Y\lambda \geq 0, \\ &\lambda \geq 0 \end{aligned} \qquad \textbf{(4.1)}$$

Where θ is a scalar and λ is a vector of constant.

The estimated value of θ is the efficiency score for bank i, where $\theta \leq 1$. When estimating the relative efficiencies for a set of homogeneous firms, a production frontier is enveloped as the production boundary of all the sample banks. Those banks with efficiency scores of 1 are technically efficient and lie on the production frontier (Farrell, 1957). Banks with efficiency scores less than 1 are relatively inefficient and deviate away from the production frontier. The DEA approach solves the programming problem as shown in equation (4.1) for I times for each of the banks.

While the CCR model assumes that all of the banks operate with constant returns to scale, Banker, Charnes, and Cooper (1984) take various external restrictions and influences into consideration and assume that there exists scale inefficiency as well as technical inefficiency in the banks during the production process.

To estimate efficiency scores for bank i, we use the VRS model. This model solves the linear programming problems in equation (4.2):

$$\begin{aligned} &min_{\theta,\lambda}\ \theta, \\ &\text{s.t}\ \theta X_i - X\lambda \geq 0, \\ &-Y_i + Y\lambda \leq 0, \\ &e\lambda = 1 \end{aligned}$$

$$\lambda \geq 0 \tag{4.2}$$

Where θ is a scalar, λ is a vector of constant, and *e* is an $I \times 1$ vector of ones.

The VRS model measures bank efficiency using a benchmark of similar-sized bank groups (Coelli et al., 2005). After excluding the impact of scale inefficiency, the technical efficiencies estimated using the VRS model are greater or equal to those estimated through the CRS model (Pasiouras, 2008).

The production possibility set T defines the possible input-output combinations attainable for all of the banks facing the current technology:

$$T = \{(X, Y) | X \geq 0, Y \geq 0, X\ can\ produce\ Y\} \tag{4.3}$$

An example of input-oriented technology possibility set under the VRS assumption is shown in Figure 4-1. Assuming there are three firms (*A, B,* and *C*) and their production process involves one input x and one output y, there is one CRS frontier and one VRS frontier. Both represent the minimum input combination for the given output level for all the sample firms. Among the three firms, firm *B* is technically efficient under both the VRS and the CRS assumption. Firms A and C are technically inefficient under both assumptions.

The overall technical efficiency (*TE*) scores obtained from the CRS model can be decomposed into the product of two components. One component is pure technical efficiency (*PTE*), which reflects the efficiency of utilising a firm's given resources. The other component is scale efficiency (*SE*), which demonstrates the ability to reach scale economies through managing the scale of operation (Coelli et al., 2005; Pasiouras, 2008). SE can be calculated as:

$$SE = \frac{TE_{CRS}}{PTE_{VRS}} \tag{4.4}$$

Therefore, the overall technical efficiency (TE), pure technical efficiency (PTE), and for each firm shown in Figure 4-1, can be represented as:

$$TE_A = \frac{FD'}{FA};\ TE_B = 1; TE_C = \frac{GE'}{GC} \tag{4.5}$$

$$PTE_A = \frac{FD}{FA};\ PTE_B = 1; PTE_C = \frac{GE}{GC} \tag{4.6}$$

$$SE_A = \frac{FD'}{FD};\ SE_B = 1; SE_C = \frac{GE'}{GE} \tag{4.7}$$

We can observe that if firm A reduces input by $\frac{DA}{FA}$ and moves to point D, firm A would be technically efficient under the VRS assumption, but not technically efficient under the CRS assumption. When

firm A further reduces input from D to D', it would be efficient under CRS, indicating that the firm is producing a constant return to scale. Similar efficiency improvements can be applied to firm C. The difference between firm A and C is that firm A is producing with increasing return to scale while firm C is producing with a decreasing return to scale.

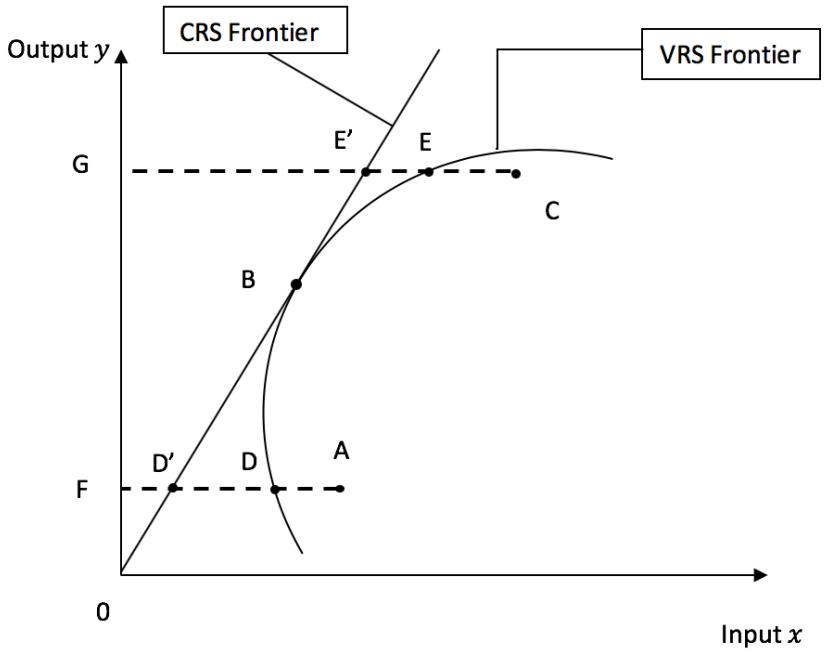


Figure 4-1 Input-orientated Technical Efficiencies (Adapted from Coelli et al., 2005)

4.3.2 Bootstrap DEA Approach and Estimation Bias

As Gijbels et al. (1999) state, efficiency scores estimated using non-parametric methods tend to be asymptotically distributed when firms operate with one input and one output. For industries with more than one input and one output, the distribution problem can be even more complicated. Simar and Wilson (2000, 2007) propose that a smoothed bootstrapping DEA model can approximate the asymptotic distribution of the efficiency estimator and provide a more reliable interpretation of efficiency scores. Another advantage of employing a bootstrap DEA model is that it can be used to estimate a confidence interval for DEA efficiency and a more precise efficiency frontier (Dyson and Shale, 2010).

In this section, we demonstrate the main steps of the bootstrapping technique to estimate efficiency in the first-stage bootstrap DEA approach. More details of the algorithm of the bootstrap DEA approach can be found in Simar and Wilson (2001, 2007)'s study.

To simplify the algorithm from Simar and Wilson (2007), efficiency estimation can be summarised in three steps. The first step is to obtain an estimated original efficiency $\hat{\theta}$ for bank i using equation

(4.1) or (4.2). Secondly, a bootstrap bias $\widehat{\mathrm{BIAS}}_{\mathrm{B}}(\hat{\theta})$ for the original DEA efficiency estimator $\hat{\theta}$ for firm i with input X_i and output Y_i can be calculated following Simar and Wilson (2007)'s approach:

$$\widehat{BIAS}_B(\hat{\theta}) = B^{-1}\sum_{b=1}^{B}\widehat{\theta^*}_b - \hat{\theta} \tag{4.8}$$

where $\widehat{\theta^*}_b$ is the bootstrap efficiency and B is the number of replications of the bootstrap procedure which usually is set as 2000.

Lastly, the bias-corrected estimator of $\hat{\hat{\theta}}$ can be calculated through:

$$\hat{\hat{\theta}} = \hat{\theta} - \widehat{BIAS}_B(\hat{\theta}) = 2 * \hat{\theta} - B^{-1}\sum_{b=1}^{B}\widehat{\theta^*}_b \tag{4.9}$$

The empirical distribution of the bias-corrected estimators can be used to construct confidence intervals of real bank efficiencies. As Simar and Wilson (1999, 2007) argue, the estimated efficiency would overestimate the actual efficiency. Assuming that $\hat{\delta} = \frac{1}{\hat{\theta}}$, and $\delta = \frac{1}{\theta}$, there would be $\hat{\theta} \geq \theta$, and $\hat{\delta} \leq \delta$. To construct the confidence interval of the efficiency score, the distribution of $\hat{\delta} - \delta$ will be:

$$Prob\left(CI_{\alpha/2} \leq \left(\hat{\delta} - \delta\right) \leq CI_{1-\alpha/2}\right) = 1 - \alpha \tag{4.10}$$

Therefore, the confidence interval can be calculated as

$$\hat{\delta} - CI_{1-\alpha/2} \leq \delta \leq \hat{\delta} - CI_{\alpha/2} \tag{4.11}$$

Converting δ back to θ using $\theta = \frac{1}{\delta}$, the confidence interval for the true efficiency score is:

$$\frac{1}{\hat{\delta} - CI_{\alpha/2}} \leq \theta \leq \frac{1}{\hat{\delta} - CI_{1-\alpha/2}} \tag{4.12}$$

The confidence interval can be constructed for each bank using the bootstrap DEA approach.

Bias-corrected efficiencies $\hat{\hat{\theta}}$ is used in the second-stage regression model as the dependent variables.

4.3.3 Cross-country Efficiency Estimation

One of the essential assumptions of the DEA approach is that all the banks are homogenous so that relative efficiencies can be estimated using a common production frontier. However, banks operating in different countries have different production opportunities due to differences in inputs, overall

macroeconomic situations, and other external environmental factors (O'Donnell et al., 2008). Using the DEA approach to estimate efficiencies of all banks using the same benchmark will lead to unreasonable interpretations (Fallah-Fini et al., 2012). Battese, Rao, and Prasada (2002) introduce the idea of meta-frontier and apply the concept to stochastic frontier analysis methods. A meta-frontier DEA framework was introduced by O'Donnell, Rao, and Battese (2008) for firms operating in different groups facing various circumstances. Understanding the gaps between group frontiers and the meta-frontier will not only help bank managers to improve banks' technical efficiency but also provide information relating to production environments (O'Donnell et al., 2008).

Similar to the conventional production possibility set as in equation (4.3), the meta-frontier production possibility set T contains all the feasible input-output combinations for banks from all different groups, which can be expressed in a simple function as:

$$T = [(X, Y)|X \geq 0, Y \geq 0, X\ can\ produce\ Y] \tag{4.13}$$

The feasible inputs to produce the output Y will be:

$$I(Y) = [X: (X, Y) \in T] \tag{4.14}$$

The input-orientated efficiency score, which gives the maximum amount of input reduction for bank i is defined as:

$$TE(X_i, Y_i) = D(X_i, Y_i) = inf_\theta[\theta > 0: (X_i * \theta) \in I(Y)] \tag{4.15}$$

An efficient bank is considered to be the best-practice bank among all of the sample banks and operates on the meta-frontier with $D(X, Y)$ equalling 1.

Assuming there are K $(K > 1)$ countries in the sample, the frontier production possibility set for country k includes all the feasible input-output combinations within the country, and the group production possibility set can be expressed as:

$$T_k = [(X, Y)|X \geq 0, Y \geq 0, X\ can\ produce\ Y\ in\ country\ k] \tag{4.16}$$

The feasible inputs of the country k and efficiency of bank i in country k can be illustrated as:

$$I_k(Y) = [X: (X, Y) \in T_k] \tag{4.17}$$

$$TE_k(X_i, Y_i) = D_k(X_i, Y_i) = inf_{\widehat{\theta^k}}[\widehat{\theta^k} > 0: \left(X_i * \widehat{\theta^k}\right) \in I_k(Y)] \tag{4.18}$$

where $k = 1, 2, \dots, K$.

Figure 4-2 shows a graphic illustration of the relationships between meta-frontier and group frontiers in a simplified situation using the VRS assumption only. It assumes there are two countries, and that bank C operating in country 1 is using input x to produce output y. The group-frontier pure technical efficiency $(GPTE)$ and meta-frontier pure technical efficiency $(MPTE)$ of bank C can be calculated as in equations (4.14) and (4.15) respectively:

$$GPTE_C^1(X_C, Y_C) = D_C^1(X_C, Y_C) = \frac{GD}{GC} \tag{4.19}$$

$$MPTE_C(X_C, Y_C) = D_C(X_C, Y_C) = \frac{GE}{GC} \tag{4.20}$$

Bank C', which operates on the country 2 group-frontier, has group-frontier pure technical efficiency and meta-frontier pure technical efficiency as:

$$GPTE_{C'}^2(X_{C'}, Y_{C'}) = D_{C'}^2(X_{C'}, Y_{C'}) = 1 \tag{4.21}$$

$$MPTE_{C'}(X_{C'}, Y_{C'}) = D_{C'}(X_{C'}, Y_{C'}) = \frac{G'E'}{G'C'} \tag{4.22}$$

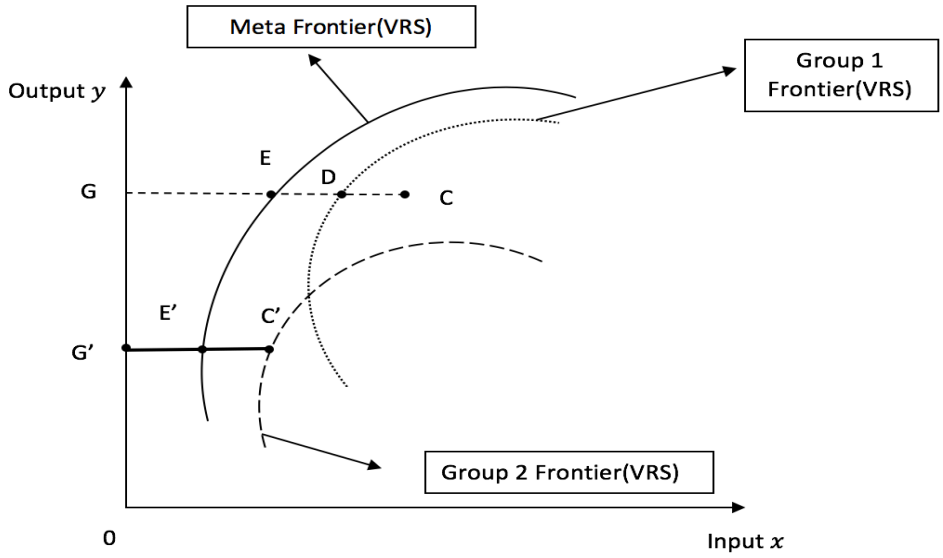


Figure 4-2 Meta-frontier and Group-frontiers (Adapted from O'Donnell et al., 2008)

There are several properties of production technologies and technical efficiencies with respect to the meta-frontier and group-frontiers (O'Donnell et al., 2008):

P.1: If $(X_i, Y_i) \in T^k$ for any group k, then $(X_i, Y_i) \in$ T;

P.2: If $(X_i, Y_i) \in T$ then $(X_i, Y_i) \in T^k$ for some group k;

P.3: $T = (T^1 \cup T^2 \cup \ldots \cup T^K)$; and

P.4: $D^k(X_i, Y_i) \geq D(X_i, Y_i)$ for banks in all k=1, 2,…,K.

Specifically, the technology gap ratio (TGR) for bank *i* in country *k* is defined as:

$$TGR_k^i(X_i, Y_i) = \frac{MPTE^i(X_i, Y_i)}{GPTE_k^i(X_i, Y_i)} = \frac{\theta}{\theta^k} \tag{4.23}$$

$TGR_k^i(X_i, Y_i)$ measures the distance between the group-frontier of country k and the meta-frontier.

For example, the technology gap ratio of bank C in country 1 can be expressed as:

$$TGR_1^C(X_C, Y_C) = \frac{D(X_C, Y_C)}{D_1(X_C, Y_C)} = \frac{MPTE^C(X_C, Y_C)}{GPTE_1^C(X_C, Y_C)} = \frac{GE}{GC} \div \frac{GD}{GC} = \frac{GE}{GD} \tag{4.24}$$

From property (P.4), we can infer that the meta-frontier technical efficiency will be smaller or equal to group technical efficiency. Therefore, the technology gap ratio of bank i equals $TGR_k^i(X_i, Y_i)$, which has the property $0 \leq TGR_k^i(X_i, Y_i) \leq 1$. When TGR_k^i equals 1, the group-frontier is tangent to the meta-frontier. In other words, the larger the TGR_k, the more advanced the technology adopted by banks in country k.

The average gap between one group-frontier and meta-frontier can be constructed as follows:

$$TGR^k = \frac{\sum_{i=1}^{I^k} TGR_k^i}{I^k} \tag{4.25}$$

Where TGR_k^i is the technology gap ratio for bank i in country k, I^k is the number of banks in country $k, i = 1, 2, \ldots, I^k$, and k = 1, 2, …, K.

4.3.4 Bootstrap Truncated Regression Model

To measure the impact of regulation, supervision, and state ownership on bank efficiency, the bootstrap truncated regression model is employed using bias-corrected bank efficiency $\hat{\hat{\theta}}$ as the dependent variable. Three bias-corrected efficiency measurements are used in the regression model: pure technical efficiency (PTE) is used to measure bank efficiency in using minimum inputs to produce a given level of outputs; scale efficiency (SE) is used to measure the efficiency of exploiting the optimal operating scale, and the technology gap ratio is used to measure the gap between technology in one country to the best production technology in the Asia-Pacific region. The regression models are specified as follows:

$$PTE_{k,i} = \beta_0 + \beta_1 * REG_k + \beta_2 * Ownership_{k,i} + \beta_3 * Bank_{i,k} + \beta_4 * Country_k + \beta_5 * YEAR\ Dummy + \beta_5 * country\ Dummy + \varepsilon_{k,i} \quad (4.26)$$

$$SE_{k,i} = \beta_0 + \beta_1 * REG_k + \beta_2 * Ownership_{k,i} + \beta_3 * Bank_{i,k} + \beta_4 * Country_k + \beta_5 * YEAR\ Dummy + \beta_5 * country\ Dummy + \varepsilon_{k,i} \quad (4.27)$$

$$TGR_{k,i} = \beta_0 + \beta_1 * REG_k + \beta_2 * Ownership_{k,i} + \beta_3 * Bank_{i,k} + \beta_4 * Country_k + \beta_5 * YEAR\ Dummy + \beta_5 * Country\ Dummy + \varepsilon_{k,i} \quad (4.28)$$

Where $PTE_{k,i}$ denotes the bias-corrected pure technical efficiency for bank i in country k, $SE_{k,i}$ denotes the bias-corrected scale efficiency for bank i in country k; $TGR_{k,i}$ denotes the bias-corrected technology gap ratio for bank i in country k. The independent variables are: REG_k is a vector of bank regulation and supervision indicators in country k, $Ownership_{k,i}$ is a dummy variable which equals 1 when the bank is classified as state-owned; $Bank_{i,k}$ is a vector of bank-specific characteristics for bank i in country k , and $Country_k$ is a vector of country-specific characteristics for country k; $YEAR\ Dummy$ is the year dummy variable from 2005 to 2014; $Country\ Dummy$ is the country dummy variable for sample countries; $\varepsilon_{k,i}$ is the error term.

4.4 Variables Selection, Sample, and Data

4.4.1 Input and Output Selection for Efficiency Estimation

There is no consensus on which are the most appropriate input and output variables for banking industries in previous studies. Berger and Humphrey (1997) note that the two main approaches for selecting inputs and outputs of bank efficiency estimations are the production approach and the intermediation approach. More recently, Drake et al. (2006) propose a profit-oriented approach and argue that this approach can capture firms' strategic responses and therefore is more suitable to dynamic changes in the environmental changes. The production approach assumes that banks use labour and capital as inputs and produce loans and deposit accounts services. While the intermediation approach considers the financial intermediation function of banks, it proposes that banks use labour and capital to transform borrowed funds into loans and other earning assets.

Based on recent literature, this study employs the intermediation approach for input and output selection. Additionally, to analyse the impact of the inclusion of off-balance sheet (OBS) activities, our study estimates bank efficiency using four models with different input and output selections and examines whether the incorporation of OBS activities significantly affect bank efficiency measurements in the Asia-Pacific region (see Table 4-1).

Table 4- 1 Inputs and Outputs Specification for Models 1 to 4

Model 1	Model 2	Model 3	Model 4
Inputs	**Inputs**	**Inputs**	**Inputs**
Fixed Assets	Fixed Assets	Fixed Assets	Fixed Assets
Total Deposits	Total Deposits	Total Deposits	Total Deposits
Noninterest Expenses	Noninterest Expenses	Noninterest Expenses	Noninterest Expenses
		Loan Loss Provision	Loan Loss Provision
Outputs	**Outputs**	**Outputs**	**Outputs**
Loans	Loans	Loans	Loans
Other Earning Assets	Other Earning Assets	Other Earning Assets	Other Earning Assets
	Off-balance Sheet Items		Off-balance Sheet Items

Source: Adapted from Pasiouras (2008).

In the base model (Model 1), we specify three inputs and two outputs in bank production procedures. The first input is "fixed assets" which describe the bank's net book value (property, plant, and equipment). The second input is "total deposits", defined as the aggregation of total customer deposits, deposits from banks, other deposits, and short-term borrowings. The third input "noninterest expenses" are the aggregation of staff expense, provisions for regulatory, legal and other expenses, other general and administrative expenses and other expenses. The first output, "loans," are the aggregation of mortgage loans, consumer loans, corporate loans, and other loans. The second output, "other earning assets," are the aggregation of derivative financial instruments, financial asset, and investment property.

To capture the impact of OBS activities on efficiency estimations, "off-balance sheet items" are considered as an additional output to describe the aggregation of guarantees, acceptances and documentary credits, committed credit facilities, managed securitised assets, other exposure to securitisations, and other bank contingent liabilities. Additionally, "loan loss provisions" are also considered to be one of the inputs which indicate problem loans in the banking industry following Charnes et al. (1990), Altunbas et al. (2000), Drake et al. (2003), Pasiouras (2008), and Hall et al. (2012).

Models 2 and 4 include off-balance sheet items as an additional output compared to Model 1 (see Table 4‑1). Furthermore, Models 3 and 4 repeat Models 1 and 2 with another addition input of loan loss provision. The definitions of the input and output variables for each country are summarised in Table 4-2.

After obtaining four sets of efficiencies using 4 different models, we employ the Kruskal-Wallis test to examine if the differences between Models 1 and 2, and Models 3 and 4 are significantly different from zero. Furthermore, we use the Skillings-Mack test to examine differences in the 4 Models to find out the ranking of efficiencies from them.

Table 4- 2 Bank Input and Output Definitions and Data Source

Variables	Definition	Data Source
Total Deposit	Total deposits and short-term funding: aggregation of total customer deposits, deposits from banks, other deposits and short-term borrowings.	BvD Bankscope
Fixed Assets	Total fixed assets net book value (property, plant, and equipment).	BvD Bankscope
Noninterest Expenses	Aggregation of staff expense, provisions for regulatory, legal and other expenses, other general &administrative expenses, depreciation and amortisation expenses and other operating expenses.	BvD Bankscope
Loan Loss Provision	Allowances for impairment loans and advances to non-specified type customers.	BvD Bankscope
Loans	Aggregation of mortgage loans, consumer loans, corporate loans, and other loans.	BvD Bankscope
Other Earning Assets	Aggregation of derivative financial instruments, financial asset, and investment property.	BvD Bankscope
Off-balance Sheet Items	Aggregation of guarantees, acceptances and documentary credits, committed credit facilities, managed securitized assets, other exposure to securitizations, and other contingent liabilities.	BvD Bankscope

Source: BvD Bankscope Database

4.4.2 Bank Regulation and Supervision Variables

Together with activity restrictions, the three pillars of the Basel Accord II are used as regulation and supervision variables in the regression models. As discussed in Chapter 1, the three pillars are capital requirements, official supervision power and market discipline. Activity restrictions in the banking industry are also included to capture restrictions imposed on non-bank activities in the Asia-Pacific banking sectors. The four indicators of bank regulation and supervision are denoted as capital regulation CAP_k, official supervisory power $SPPOWER_k$, market discipline $MKDSPL_k$, and activity restrictions $ACRS_k$. Bank regulation and supervision data are obtained primarily from the Bank Regulation and Supervision Survey (Barth et al., 2007, 2012).

Based on Barth et al. (2001, 2006, 2008, 2012)'s descriptions, regulation and supervision variables are constructed through assigning "1" or "0" to several survey questions, where regulation and supervision authorities from various countries give answers of "yes" or "no". Appendix A-1 provides a list of survey questions for each of the regulation and supervision variables used in this study.

CAP_k is the index of capital regulation to measure the initial and overall capital requirements for banks in country k. This index is constructed using answers from five survey questions. The range of the capital requirement is from 0 to 7. A higher value indicates more stringency in the country's capital regulation.

$SPPOWER_k$ assesses the extent of official supervisory power to oversee, monitor, and discipline managers, directors, and auditors of banks in country k. Fourteen questions are surveyed to obtain the value of supervisory power. Variables range from 0 to 14 for each country. Similar to capital requirements, higher values show stronger supervisory power from regulation authorities. $MKDSPL_k$ is used to measure information disclosure to shareholders, auditors, and the public and whether any credit ratings are required by regulatory authorities for banks in country k. There are seven questions in this variable. Therefore, the value of market discipline ranges from 0 to 7. A higher value indicates a more informative and transparent banking industry.

$ACRS_k$ is the proxy of non-bank activity restrictions in real estate investment, insurance underwriting and selling, brokering and dealing securities, and all aspects of mutual fund industries in country k. For each category of activities, there are four answers to choose from: 1 (unrestricted), 2 (permitted); 3 (restricted); and 4 (prohibited). Thus, the value of $ACRS_k$ ranges from 0 to 12. A higher value of activity restriction indicates more restrictions on nonbank activities in the banking industry.

The Bank Regulation and Supervision Survey (2011) database does not include information for Japan and Singapore. The author manually collected this data using bank regulation laws, other legal documents and reports from international institutions such as the Basel Committee of Banking Supervision and IMF updated from 2008 to 2012. Appendix A-2 lists all of the related documents, providing regulation and supervision information for Japan and Singapore for the data collected. For each question, if there is no related official document, updated between 2008 and 2012, we consider that the answer remains the same as in the 2007 survey. The collected information for the Japanese and Singaporean banking industries from 2009 to 2014 shows that regulation and supervision in capital requirement has been tightened since both countries have applied Basel II and part of Basel III recommendations at the end of 2011. Other regulation and supervision in activity restrictions, official supervision power, and market discipline did not change between these two time periods. Table 4-3 summarises the regulation and supervision data for each country from 2005 to 2008 and from 2009 to 2014.

Table 4- 3 Regulation and Supervision for Sample Countries for Two Time Periods

Country	Capital Regulation		Activity Restrictions		Official Supervision Power		Market Discipline	
	2005-2008	2009-2014	2005-2008	2009-2014	2005-2008	2009-2014	2005-2008	2009-2014
Australia	2	5	8	6	13	11	6	6
China	1	5	11	10	11	11	6	6
Hong Kong	1	5	3	3	11	9	6	6
Indonesia	2	5	12	7	13	13	4	5
Japan	1	5	8	8	12	12	5	5
New Zealand	1	4	4	5	7	9	6	5
Singapore	4	5	7	7	13	13	5	5
Thailand	1	5	10	8	10	14	5	5

Source: Data from 2005 to 2008 are obtained from the Bank Regulation and Supervision Survey (2007); data from 2009 to 2014 are obtained from the Bank Regulation and Supervision Survey (2011).

4.4.3 State Ownership

The variable $Ownership_{k,i}$ is used in the regression models to examine the relationship between bank ownership and efficiency. Historical ownership data for each sample bank is obtained from the BvD Bankscope database. The global ultimate ownership (GUO) of banks and historical information of direct owners are considered when constructing the variable. Since 20% of the ownership is typically sufficient to have control rights in the banks' operation decisions (La Porta et al., 1998), the benchmark of 20% is used in this study to identify whether the government has control rights. For each bank, shareholders with shares of more than 3% in the bank are considered each year. If the shareholder is a central government, local government, or sole state-owned enterprise in country k, the shareholder is regarded as the government. The variable $Ownership_{k,i}$ equals one when the aggregate ownership of government in the bank i of country k is greater than 20%. Similarly, we also identify foreign-owned banks for comparison. A bank is identified as foreign-owned when a single foreign shareholder owns more than 20% of the bank share. If the bank is neither state-owned nor foreign-owned, it is classified as a privately-owned bank. Table 4-4 provides a summary of the number of state-owned banks in each country from 2005 to 2014.

Table 4- 4 Number of State-owned Banks in Each Country from 2005 to 2014

Year	Australia	China	Hong Kong	Indonesia	Japan	New Zealand	Singapore	Thailand
2005	0	7	0	4	0	0	0	2
2006	0	7	0	6	0	0	0	2
2007	0	8	0	4	0	1	0	2
2008	0	11	0	6	0	1	0	2
2009	0	12	0	7	0	0	0	4
2010	0	11	0	10	1	0	0	5
2011	0	10	0	8	0	0	1	4
2012	0	14	0	9	0	0	1	3
2013	0	14	0	10	0	0	0	5
2014	0	14	0	9	0	0	0	4
Total	0	108	0	73	1	2	2	33

Source: Calculated by the author using data from BvD Bankscope.

4.4.4 Bank-specific Characteristics

To control the impact from other bank-specific characteristics on bank efficiency, this study uses a set of bank-specific variables $Bank_{i,k}$ in the regression models. The bank-specific variables are $Banksize_{i,k}$; $EQTA_{i,k}$; $OBSTA_{i,k}$; $LLPTL_{i,k}$; $LIQTA_{i,k}$.

$Banksize_{i,k}$ is calculated as the logarithm of total assets to capture banking scale characteristics. Empirical results from previous studies show mixed results in terms of bank size and efficiency. While Bonin et al. (2005), Lin et al. (2016) find that smaller banks are more efficient, more studies (Radic et al., 2012; Luo et al. 2016, etc.) identify a positive relationship between bank size and efficiency.

$EQTA_{i,k}$ is proxied as the ratio of total equity, divided by total assets, to control the level of capitalisation in banks. Bank capitalisation can affect the banks' ability to optimise resources and maximise profits (Silva et al., 2016). Generally, a well-capitalised bank is expected to have better risk management strategies (Das and Ghosh, 2006), and influence bank efficiency.

The other three variables are used to capture three types of risks in banks. The first variable is $OBSTA_{i,k}$, is calculated as off-balance sheet items divided by total assets. A higher $OBSTA_{i,k}$value suggests higher risks accompanied by higher ratio of off-balance sheet activities. The second variable, risk proxy $LLPTL_{i,k}$ is used to capture credit risk, calculated by using loan loss provisions over total loans. A higher $LLPTL_{i,k}$value indicates higher bank credit risk.

Since these two risk measurements can be correlated with off-balance sheet (OBS) activities and loan loss provisions (LLP) in efficiency estimations, $OBSTA_{i,k}$ and $LLPTL_{i,k}$ are only included in regression models where OBS and LLP are not considered in efficiency estimations.

The last risk measurement is $LIQTA_{i,k}$ and controls bank liquidity risk levels. This is calculated by liquid assets over total assets. A higher $LIQTA_{i,k}$ value indicates lower liquidity risk in bank i in country k.

4.4.5 Country-specific Variables

Except for bank-specific variables, country-specific variables are also included in regression models to account for variations in bank operating environments. This study considers four country-level variables: real GDP growth GDP_growth_k, inflation rate INF_k, concentration HHI_k, banking industry development $PrCrGDP_k$, and institutional governance environment INS_ENV_k.

Since the development levels for Asia Pacific countries vary across different countries, it is essential to include macroeconomic environmental variables in the regression to capture economic features.

The first country-specific variable, GDP_growth_k is measured as the annual growth rate of GDP to control for macroeconomic conditions of the country. A higher GDP_growth_k value will affect the country's macroeconomy in a favourable way. However, the relationship of the GDP growth rate with bank efficiency are mixed in previous studies. Additionally, inflation INF_k is measured by the annual rate of the implicit GDP deflator. Higher inflation rates indicate a rapid price increase in the country which will affect bank efficiency through changes in market behaviour (Kasman and Yildirim, 2006).

Furthermore, variables of the banking industry are also included in the regression models. The first variable is concentration (Herfindahl Hirschman Index-HHI). HHI_k, is calculated as the sum of square for deposit shares for each bank in all of the banks in that country:

$$HHI_k = \sum_{i=0}^{I} \left(\frac{Deposit_i}{\sum_{i=0}^{I} Deposit_i}\right)^2 \tag{4.29}$$

Higher concentration can be related to lower efficiency due to excessive market power and less competition. In contrast, a high concentration can be a result of efficient bank operations. The quiet life hypothesis (Hick, 1935) suggests that banks become inefficient because of less competition, while Fries and Taci (2005) believe that high concentration is the result of efficient operations.

The $PrCrGDP_k$ describes the level of bank claims to the private sector to GDP, which is used to capture the intermediation activities of the banking industry in one country (Pariouras, 2008). High levels of intermediation activities in the banking industry can be caused by high efficiency in the

banking industry. However, these activities can also lead to high risks in the banking industry and therefore impede bank efficiency (Lozano-Vivas and Pasiouras, 2010).

The last variable, institutional governance indicator INS_ENV_k is used to control the institutional environment for countries. Initially, there are six dimensions of governance environment: voice and accountability (Voice), political stability and absence of violence/terrorism (Stability), government effectiveness (Gov_Eff), regulatory quality (Reg_Qua), the rule of law (Rule_Law), and control of corruption (Corruption) (see Appendix A-3 for definition). Each of these variables range between -2.5 and 2.5. A larger value indicates more effective governance in the country. Since these six variables are highly correlated, as shown in Table 4-5, we employ principal component analysis to create a new variable INS_ENV_k to capture the information of all of these six variables to represent the comprehensive institutional governance environment in country k. Table 4-6 shows 92.15% of the variation of the six original governance indexes are captured using the first component. INS_ENV_k can be used to represent information about the institutional environment of the banking industry.

Table 4- 5 Correlation between Institutional Governance Variables

	Corruption	Gov_Eff	Stability	Reg_Qua	Rule_Law	Voice
Corruption	1					
Gov_Eff	0.9849	1				
Stability	0.9531	0.948	1			
Reg_Qua	0.9667	0.964	0.9107	1		
Rule_Law	0.9898	0.9852	0.9528	0.9727	1	
Voice	0.8006	0.7487	0.7586	0.7758	0.832	1

Source: Calculated by the author based on information from the World Governance Indicators database.

Table 4-6 Results of Principal Component Analysis in Institutional Governance Indexes

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	5.52926	5.19735	0.9215	0.9215
Comp2	0.33191	0.24007	0.0553	0.9769
Comp3	0.0918397	0.0611169	0.0153	0.9922
Comp4	0.0307228	0.018705	0.0051	0.9973
Comp5	0.0120178	0.00776471	0.002	0.9993
Comp6	0.00425309	.	0.0007	1

Source: Calculated by author employing econometric software Stata 14.

4.4.6 Data Collection

The bank-level financial data used in this study comprised of data from unconsolidated statements of individual banks taken from the BvD Bankscope database. When unconsolidated statements are not available, consolidated statements are used instead. Only active commercial banks in Australia,

China, Hong Kong, Indonesia, Japan, New Zealand, Singapore, and Thailand are chosen for the study. The initial sample data contains 561 banks with 5610 observations. To capture overall banking industry characteristics, observations with less than three consecutive years of available data are deleted. Therefore, our sample decreases from 5610 to 3749 observations for 544 banks. Due to the data requirements of the DEA approach, observations with missing values, zero, or negative values in all of the inputs or outputs variables (see Table 4-1) are dropped. As a result, a total sample of 2186 bank-year observations is obtained.

Table 4-7 provides an overview of the number of observations for each country in each year. All of the financial data are winsorised at the 1st and 99th percentile level of their distributions to reduce the influence of outliers and potential data errors (Anginer, Demirguc-Kunt, and Zhu, 2014).

Data on bank regulation and supervision is obtained from the Bank Regulation and Supervision Survey (2007, 2011). Considering changes in bank regulatory and supervisory policies in most countries, in response to the 2008 GFC, regulation and supervision data from the 2007 survey are used for each country, from 2005 to 2008, and regulation and supervision data obtained from the 2011 survey are used for each country, from 2009 to 2014.

Bank ownership data is constructed using ownership information provided in the BvD Bankscope database. Except for concentration, data of country-specific variables are obtained from the Global Financial Development database. Table 4-8 provides details of the definition and source of each variable used in this study.

Table 4-7 Observations for Each Country from 2005 to 2014

year	Australia	China	Hong Kong	Indonesia	Japan	New Zealand	Singapore	Thailand
2005	6	17	13	22	88	0	4	9
2006	13	19	15	26	91	1	5	13
2007	12	25	16	24	83	5	4	14
2008	14	41	19	34	63	4	6	13
2009	12	39	16	34	92	3	8	13
2010	14	55	14	35	89	4	6	16
2011	13	53	14	36	97	5	5	18
2012	11	72	18	36	76	7	4	19
2013	10	80	14	42	90	8	7	19
2014	12	88	17	44	72	6	5	20
Total	117	489	156	333	841	43	54	154
No. of banks	18	97	22	49	109	9	9	20

Source: Author's calculations.

Table 4-8 Definition and Data Source of Variables used in Regression Models

Variables	Definition	Data Source
Regulation and supervision		
CAP_k	Initial and overall capital requirements for banks in country k.	Bank Regulation and Supervision Survey (2007, 2011)
$SPPOER_k$	Extent of official supervision power to oversee, monitor, and discipline managers, directors, and auditors of banks in country k.	Bank Regulation and Supervision Survey (2007, 2011)
$MKDSPL_k$	Information disclosure to regulators, shareholders, auditors, and public and whether any credit ratings are required for banks in country k.	Bank Regulation and Supervision Survey (2007, 2011)
$ACRS_k$	Bank activity restrictions in real estate investment, insurance underwriting and selling, brokering and dealing securities, and all aspects of mutual fund industries in country k.	Bank Regulation and Supervision Survey (2007, 2011)
Ownership Variable		
$Ownership_{k,i}$	State ownership of the bank, which equals1 when bank is state-owned, otherwise 0.	Caculated based on information from BvD Bankscope
Bank-specific Variables		
$Banksize_{i,k}$	Bank size, calculated as logarithm of the total assets of the bank.	BvD Bankscope
$EQTA_{i,k}$	Bank capitalisation, calculated as total equity divided by total assets.	BvD Bankscope
$OBS_{i,k}$	Bank operating risk, calculated as off-balance sheet items divided by total assets.	BvD Bankscope
$LLPTL_{i,k}$	Bank credit risk, calculated as loan loss provisions over the total loans.	BvD Bankscope
$LIQTA_{i,k}$	Bank liquidity risk, calculated as liquid assets over the total assets.	BvD Bankscope
Country-specific Variables		
GDP_growth_k	Real GDP growth in the country.	Global Financial Development Database
INF_k	Annual rate of the implicit GDP deflator.	Global Financial Development Database
HHI_k	Herfindall Hirschman Index, calculated as sum of square for deposit shares for each bank in all banks in the country.	Calculated by author using data from BvD Bankscope
$PrCrGDP_k$	Bank claims to the private sector to GDP.	Global Financial Development Database
INS_ENV_k	Institutional governance index, consisting of voice and accountability, political stability and absence of violence or terrorism, government effectiveness, regulatory quality, the rule of law, control of corruption.	Calculated using data from World Governance Indicators database

4.5 Analytical Framework

The analytical framework used in this study includes the following steps:

(1) Four sets of inputs and outputs variables in 4 different models are used in bootstrap DEA to estimate bias-corrected PTE-pure technical efficiency (under the VRS assumption), and bias-corrected TE-technical efficiency (under the CRS assumption), under both group and meta frontiers. The SE-scale efficiencies are calculated using the bias-corrected PTE and TE.

(2) Bias-corrected meta-frontier PTE estimated from step (1) for Models 1 to 4 are compared using the Kruskal-Wallis and Skillings-Mack tests to examine the impact of including off-balance sheet items and loan loss provisions.

(3) Technology gap ratio, bias-corrected meta-frontier PTE, and scale efficiency are calculated and used as the dependent variable in the bootstrap truncated regression to examine the relationship between regulation, supervision, ownership and bank efficiency.

This study uses two econometric programmes to conduct data analysis. For the bootstrap DEA approach, we use R software with the Benchmarking package (Bogeetoft and Otto, 2015). For the second stage analysis, we use the STATA 14 to conduct the bootstrap truncated regression.

Chapter 5

Empirical Results and Interpretation

5.1 Introduction

Chapter 5 provides the empirical results based on the methodology described in Chapter 4. Section 5.2 presents the descriptive statistics of the main variables and summarises the regulation and supervision of eight countries in the Asia-Pacific over the period of 2005 to 2014. Section 5.3 discusses bank efficiency estimations based on the DEA approaches. Section 5.4 describes the relationship between bank regulation, state ownership and bank efficiency. Lastly, section 5.4 reports the robustness check results.

5.2 Descriptive Statistics

5.2.1 Input and Output Variables

Table 5-1 shows the mean and standard deviation of each input and output variable for efficiency estimations, from 2005 to 2014, in eight sample countries. The sample countries include Australia, China, Hong Kong, Indonesia, Japan, New Zealand, Singapore, and Thailand. All of the data are obtained from the BvD Bankscope database and data has been adjusted with the GDP deflator in 2005.

Based on the results in Table 5-1, the banking industries in the Asia-Pacific region have distinctive input and output levels. For example, Australian and Chinese banks have higher average mean values in almost every input or output variable compared to those in other countries. The Indonesian banking industry has the lowest mean value in both input and output variables, suggesting that they operate in relatively small sizes. Interestingly, Australian banks have a lower levels of fixed assets compared to the average value in the Asia-Pacific region. While Chinese banks have higher loan levels and other earning assets, their off-balance sheet activities are much lower than Australia and Singapore over the study period. Table 5-2 provides descriptive statistics pertaining to input and output variables for the full sample. Statistics include mean, standard deviation, and minimum and maximum values.

Table 5- 1 Descriptive Statistics of the Inputs and Outputs of Sample Countries (2005-2014)

Country	Statistics	Total Deposit	Fixed Assets	Personnel Expenses	Loan Loss Provision	Loan	Other Earning Assets	Off-Balance Sheet Items
Australia	Mean	119925.97[8]	525.17	2295.15	423.15	132601.72	42663.09	41064.98
	SD	171062.66	809.97	3086.38	699.78	185761.60	66925.25	61181.78
China	Mean	140761.76	1382.91	1561.70	475.33	77662.55	56261.29	28261.16
	SD	398160.21	4376.84	4481.71	1377.94	227880.48	148232.35	72772.32
Hong Kong	Mean	58748.84	1074.02	827.60	77.94	33231.50	33952.47	23702.26
	SD	111372.23	2259.53	1776.36	186.40	60177.80	72961.03	48735.54
Indonesia	Mean	5193.14	77.31	213.75	50.09	3785.31	1919.78	1023.44
	SD	9574.68	136.53	381.68	105.72	6837.52	3793.39	2243.81
Japan	Mean	62575.04	599.34	665.94	115.89	38806.36	27931.16	1886.14
	SD	187495.23	1409.91	1819.04	458.85	103518.15	115738.27	9443.68
New Zealand	Mean	24435.16	83.27	417.44	73.92	28041.19	5561.96	7285.93
	SD	21339.89	82.21	392.10	115.38	24909.42	5818.29	7534.76
Singapore	Mean	79364.16	571.71	1109.08	164.92	55847.86	37688.50	38116.48
	SD	78267.78	588.66	992.32	210.78	58984.14	35622.21	40579.64
Thailand	Mean	17511.37	323.19	443.97	139.84	14807.83	5615.62	10761.97
	SD	17884.44	385.16	447.27	153.88	14591.84	6422.86	17759.35

Notes: All the data are real value in million US dollars adjusted based on the GDP deflator in 2005 for each country over the period of 2005 to 2010. Mean=mean; SD=standard deviation; Max=maximum value; Min=Minimum value.

Source: Calculated by the author with data from the BvD Bankscope database.

[8] Australian banks have been using external funding from wholesale debt securities and securitizations as the part of the source of loans and the loan-to-deposit ratio has been among one of the highest in the world (Concern Australian, 2013).

Table 5- 2 Descriptive Statistics of the Inputs and Outputs in the Asia-Pacific Region (2005-2014)

Variables	Mean	SD	Max	Min
Inputs				
Total Deposits	86,068.17	279,580.74[9]	3,368,189.83	23.11
Fixed Assets	709.95	2,472.14	32,567.41	0.07
Noninterest Expenses	896.90	2,698.78	31,232.88	0.90
Loan Loss Provisions	209.44	782.56	10,632.95	0.00
Outputs				
Loans	45,788.47	141,244.02	1,759,887.29	6.09
Other Earning Assets	30,315.82	107,021.11	2,247,399.26	9.06
Off-balance Sheet Items	13,047.35	43,863.62	537,704.05	0.00

Notes: All of the data are real value in million US dollars adjusted based on the GDP deflator in 2005 for each country over the period of 2005 to 2010. Mean=mean; SD=standard deviation; Max=maximum value; Min=Minimum value.

Source: Calculated by the author using data from the BvD Bankscope database.

5.2.2 Regulation, Supervision, State Ownership and Control Variables

The regulation and supervision data are obtained from the Bank Regulation and Supervision survey (2007 and 2011) for each country. The four regulatory indexes included in this study are capital stringency, official supervision power, regulation to enhance market discipline (hereafter referred to as market discipline), and activity restrictions. Furthermore, we include a dummy variable (the deposit insurance scheme), which is usually considered another type of government involvement in the banking system.

Table 5-3 and Figure 5-1 provide a summary of regulation and supervision data for each country over the two time periods: 2005-2008 and 2009 to 2014. Compared to other countries, regulatory authorities have more power in Australia, China, Indonesia, and Singapore, while supervisory power is lowest in New Zealand. China has the highest activity restrictions in the banking industry, while New Zealand imposes the least restrictions on non-bank activities. Capital regulation and market discipline in the sample countries are quite similar, except that Singapore has tighter capital regulation than other countries from 2005 to 2008. Consistent with Barth et al. (2013)'s descriptions, all of our sample countries imposed restrictive capital regulations after the 2008 financial crisis.

After the 2008 GFC, regulatory authorities in New Zealand and Thailand gain more official supervision power in the banking industry. In contrast, Australia and Hong Kong supervisors have less supervisory

[9] Previous literature (see for example: Ab-Rahim et al., 2012; Lin et al., 2016) showed similar situations where the mean value of inputs and outputs in banks are smaller than their standard deviation.

power, and other countries exhibit no changes. Overall, there is no significant changes to activity restrictions in the banking industry from 2007 to the 2011 survey. Except for Indonesia (which tightens) and New Zealand (which loosens), market discipline policies in other sample countries remain the same across the two study periods. Restrictions in bank activities, securities, insurance, and real estate businesses, are loosened for banks in Australia, China, and Indonesia. After the 2008 GFC, New Zealand banks face more non-bank restrictions, while restrictions in other countries remain the same.

Table 5-3 Regulation and Supervision of Sample Countries (2005 to 2014)

Country	Capital Stringency		Supervision Power		Market Discipline		Activity Restriction	
	2005-2008	2009-2014	2005-2008	2009-2014	2005-2008	2009-2014	2005-2008	2009-2014
Australia	2	5	13	11	6	6	8	6
China	1	5	11	11	6	6	11	10
Hong Kong	1	5	11	9	6	6	3	3
Indonesia	2	5	13	13	4	5	12	7
Japan	1	5	12	12	5	5	8	8
New Zealand	1	4	7	9	6	5	4	5
Singapore	4	5	13	13	5	5	7	7
Thailand	1	5	10	14	5	5	10	8

Notes: The survey questions in the Bank Regulation and Supervision Survey in 2011 are slightly different from those in 2007. To maintain the consistency of the variables, we use survey questions from the 2007 Survey. Generally, a higher regulation and supervision index score indicates tighter regulation and supervision.

Source: Bank Regulation and Supervision Survey (2007 and 2011) and author's calculation based on the laws and official documents (see Appendix A-2) for the Japanese and Singaporean banking industry.

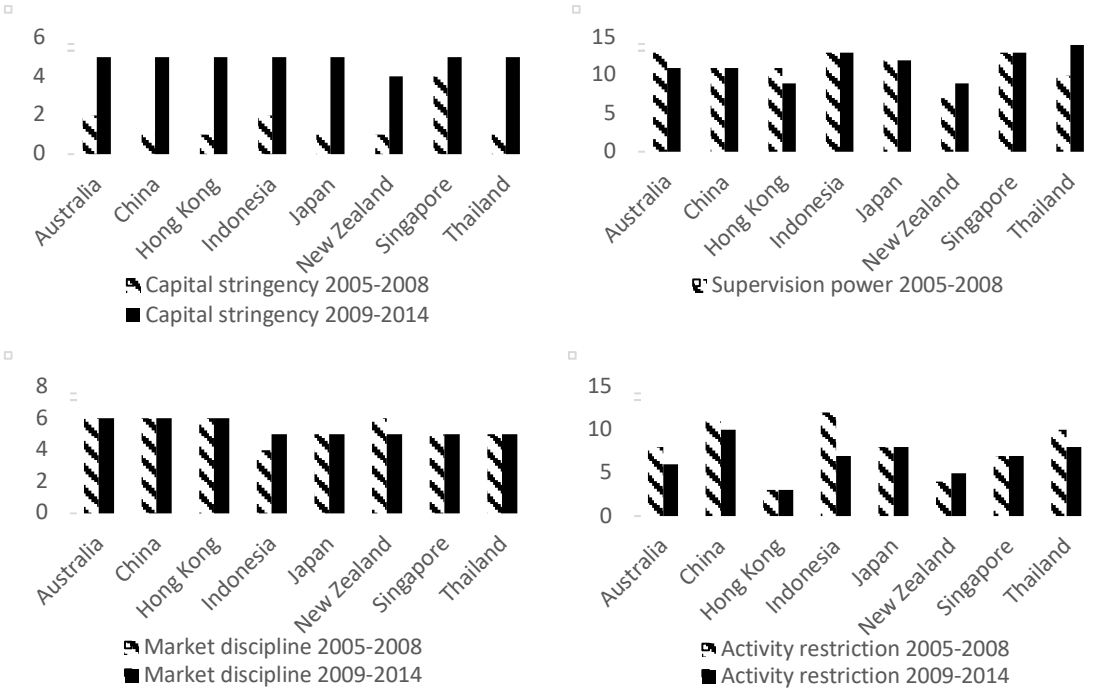


Figure 5-1 Regulation and Supervision for Sample Countries (2005 to 2014)

Table 5-4 displays deposit insurance schemes in each sample country from 2005 to 2014. Deposit insurance schemes vary among the sample countries in the Asia-Pacific region. Except for China and New Zealand, all other six countries have explicit deposit insurance schemes at the end of 2014. Japan adopted the deposit insurance scheme in 1971; Hong Kong and Indonesia in 2004; Singapore in 2006; and Australia and Thailand in 2008, respectively.

Table 5-4 Deposit Insurance Schemes in Sample Countries (2005 to 2014)

Country	Explicit Deposit Insurance Schemes (1=Explicit; 0=implicit)									
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Australia	0	0	0	1	1	1	1	1	1	1
China	0	0	0	0	0	0	0	0	0	0
Hong Kong	1	1	1	1	1	1	1	1	1	1
Indonesia	1	1	1	1	1	1	1	1	1	1
Japan	1	1	1	1	1	1	1	1	1	1
New Zealand	0	0	0	0	0	0	0	0	0	0
Singapore	0	1	1	1	1	1	1	1	1	1
Thailand	0	0	0	1	1	1	1	1	1	1

Notes: New Zealand started an opt-in deposit insurance scheme in October 2008 and terminated it in December 2010. From 2008 to 2010, the Australian dollar-dominated deposits in New Zealand branches of Australian banks are covered by the deposit insurance scheme.

Source: Data from 2005 to 2013 are obtained from the deposit insurance database (Demirguc-Kunt, Kane, and Laeven, 2013). Information from the regulation and supervision authorities' official websites are used as a supplement for 2014.

Table 5-5 provides the descriptive statistics of the regression models' independent variables for the full sample over the period of 2005 to 2014. Table 5-6 summarises the mean and statistics of the bank- and country-specific variables for each country (2005 - 2014).

Table 5- 5 Descriptive Statistics of Regression Model Independent Variables

Variables	Mean	SD	Max	Min
Regulation and Supervision				
CAP	3.7683	1.7702	5	1
SPPOWER	11.7669	1.1598	14	7
ACRS	8.1163	2.0572	12	3
MKDSPL	5.3054	0.5554	6	4
DEP_INS	0.7239	0.4472	1	0
Ownership				
STATE	0.1003	0.3004	1	0
Bank-specific				
BANKSIZE	16.6697	1.8822	21.9376	10.048
EQTA	0.0876	0.0747	0.81	0.0035
OBSTA	0.1591	0.3874	13.2399	0
LLPTL	0.0061	0.0082	0.0797	0
LIQTA	0.1594	0.1295	0.8454	0.0014
Country-specific				
GDP_growth (%)	3.9979	3.9893	15.2404	-5.4171
INF (%)	2.631	4.378	18.1498	-1.8957
HHI	0.1375	0.0784	1	0.064
PrCrGDP (%)	98.7247	37.2066	219.12	22.31
INST_ENV	-0.6172	2.1847	2.5613	-3.7848

Notes: Mean=mean; SD=standard deviation; Max=maximum; Min=Minimum.

Source: Regulation and supervision data are obtained from the Bank Regulation and Supervision Survey (2007, 2011). Bank-specific variables and HHI are calculated using data from the BvD Bankscope database. Data for GDP_growth, INF, PrCrGDP are obtained from the Global Financial Development Database. Data of INST_ENV is the result of the principal component analysis from 6 indicators of World Governance Indicators.

Table 5-6 Descriptive Statistics of Bank- and Country-specific Variables for Sample Countries (2005-2014)

Variable	Statistics	Australia	China	Hong Kong	Indonesia	Japan	New Zealand	Singapore	Thailand
Bank-specific									
BANKSIZE	Mean	17.38	16.96	16.82	14.67	17.23	16.06	17.51	16.21
	SD	(2.17)	(2.10)	(1.86)	(1.62)	(1.11)	(2.72)	(1.81)	(1.47)
EQTA	Mean	0.08	0.09	0.11	0.13	0.05	0.19	0.10	0.14
	SD	(0.04)	(0.07)	(0.08)	(0.06)	(0.01)	(0.24)	(0.04)	(0.12)
OBS	Mean	0.17	0.21	0.29	0.15	0.01	0.14	0.29	0.62
	SD	(0.12)	(0.13)	(0.16)	(0.12)	(0.03)	(0.09)	(0.20)	(1.28)
LLPTL	Mean	0.0048	0.0075	0.0037	0.0118	0.0033	0.0019	0.0028	0.0108
	SD	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)
LIQTA	Mean	0.11	0.25	0.29	0.22	0.07	0.15	0.21	0.13
	SD	(0.07)	(0.11)	(0.15)	(0.11)	(0.07)	(0.16)	(0.16)	(0.07)
Country-specific									
GDP_growth (%)	Mean	2.84	9.15	3.78	5.69	0.62	1.98	5.69	3.47
	SD	(0.69)	(1.86)	(2.96)	(0.54)	(2.49)	(1.33)	(4.57)	(2.74)
INF (%)	Mean	3.45	3.86	1.63	9.71	-0.76	2.58	1.18	2.88
	SD	(2.05)	(2.98)	(1.61)	(4.85)	(0.90)	(1.86)	(2.03)	(1.62)
HHI	Mean	0.24	0.13	0.29	0.11	0.10	0.32	0.31	0.12
	SD	(0.11)	(0.04)	(0.06)	(0.02)	(0.02)	(0.12)	(0.03)	(0.01)
PrCrGDP	Mean	116.77	118.62	165.74	25.44	100.25	135.46	99.03	99.50
	SD	(7.67)	(10.04)	(31.48)	(3.16)	(3.91)	(6.96)	(14.40)	(7.41)
INST_ENV	Mean	1.93	-3.14	1.66	-3.05	1.08	2.37	1.83	-2.56
	SD	(0.05)	(0.09)	(0.10)	(0.33)	(0.15)	(0.13)	(0.11)	(0.16)

Notes: Mean=mean; SD=standard deviation.

Source: Bank-specific variables and HHI are calculated using data from the BvD Bankscope database. Data for GDP_growth, INF, PrCrGDP are obtained from the Global Financial Development Database. Data of INST_ENV is the result of the principal component analysis from 6 indicators of World Governance Indicators.

5.3 Bank Efficiency Estimation

As described in Chapter 4, there are two types of technical efficiency estimated using the DEA approach based on CRS (constant returns to scale) and the VRS (variable returns to scale) assumptions: TE (overall technical efficiency based on CRS assumption) and PTE (pure technical efficiency based on VRS assumption). Combined with our previous discussion of the meta-frontier and group-frontier DEA approach, there are four types of efficiency estimates: meta TE (CRS meta-frontier overall technical efficiency), meta PTE (VRS meta-frontier pure technical efficiency), group TE (CRS group-frontier overall technical efficiency), and group PTE (VRS group-frontier pure technical efficiency). Furthermore, based on these four efficiency estimates, we can calculate the SE (scale efficiency) and TGR (technology gap ratio). The following sections provide results and discussions of these efficiency estimates[10].

Table A-4 in the Appendix shows details of the confidence interval of bias-corrected PTE average banks in each country under Models 1 to Model 4. Most of the PTE, using the traditional DEA approach, lie beyond the 95% confidence interval, suggesting that using efficiency estimates without bias-correction might lead to incorrect inference.

5.3.1 Bank Efficiency with Non-traditional Activities

To examine the impact of including off-balance sheet (OBS) activities on bank efficiency estimations, Table 5-7 presents the average TE (technical efficiency), PTE (pure technical efficiency), and SE (scale efficiency) scores in 4 different models, before and after the bias-correction, relative to the meta-frontier.[11] After bias-correction, the TE, PTE and SE estimates have smaller means and standard deviations, which is supports Fallah-Fini et al. (2012)'s statement that banks appear to be efficient under traditional DEA approach but might not be efficient using the bootstrap DEA approach. As Simar and Wilson (2008) and Fallah-Fini et al., (2012) explain, one possible reason for the existence of such a large bias is that there are not enough observations to construct the correct frontier.

[10] The R software and package Benchmarking (Bogeetoft and Otto, 2015) are employed to conduct bootstrap DEA estimations.

[11] In this section, we use efficiency estimated relative to meta-frontier only, since these efficiencies are comparable within the region and suitable for calculating the means of the entire region.

Table 5-7 Average Technical Efficiency, Pure Technical Efficiency, and Scale Efficiency of 4 Models[12]

	Without Considering Risk		With Considering Risk	
	Model 1 Without OBS	Model 2 With OBS	Model 3 Without OBS	Model 4 With OBS
Panel A: Bootstrap DEA Approach				
TE	0.5735 (0.1233)	0.5824 (0.1206)	0.6067 (0.1371)	0.617 (0.1354)
PTE	0.8025 (0.1257)	0.8290 (0.1233)	0.8161 (0.1213)	0.8459 (0.1173)
SE	0.7196 (0.1290)	0.7074 (0.1250)	0.7689 (0.2478)	0.7322 (0.1334)
Panel B: Traditional DEA Approach				
TE	0.6337 (0.1376)	0.6481 (0.1392)	0.6725 (0.1609)	0.6891 (0.1609)
PTE	0.8453 (0.1346)	0.8748 (0.133)	0.863 (0.1323)	0.8936 (0.1282)
SE	0.7546 (0.1306)	0.7468 (0.1364)	0.8062 (0.265)	0.7738 (0.1461)

Notes: TE= overall technical efficiency; PTE = pure technical efficiency; SE = scale efficiency. Standard deviations are shown in the parenthesis. Models 1 to Model 4 use different inputs and outputs specifications (see Table 4-1 in Chapter 4)

Source: Author's calculations.

Without considering the asset quality of the banking industry, the comparisons between bank efficiencies of Models 1 and 2 show similar results under both the bootstrap DEA and the traditional DEA approach. After including OBS activities, the average TE and PTE estimates in Model 2 are higher than those in Model 1, and the average SE estimates in Model 2 are lower than those in Model 1. Similarly, compared to Model 3, the average TE and PTE estimates are higher, and the average SE estimates are lower in Model 4. To test whether differences in bank efficiencies are significantly different from zero, we follow Lozano-Vivas and Pasiouras (2010) and conduct the Kruskal-Wallis tests for comparison between Models 1 and 2, as well as Models 3 and 4. The results are displayed in Table 5-8. Under the bootstrap DEA approach, all three bank efficiencies are significantly different after including OBS activities, with or without considering risks at a 5% significance level. However, under the traditional DEA approach, the difference in SE estimates in Models 3 and 4 are not significantly different from zero, suggesting that the inclusion of OBS do not affect SE estimates when considering loan loss provisions and when employing the traditional DEA approach. The significant differences provide support for the bootstrap DEA approach in efficiency estimation, rather than the traditional DEA approach.

[12] Model 1 excludes both OBS and LLP in the efficiency estimation; Model 2 includes OBS and excludes LLP in the efficiency estimation; Model 3 consists of the LLP but excludes the OBS in the estimation; Model 4 includes both OBS and LLP in the estimation.

The overall results indicate that the inclusion of OBS activities will affect bank efficiency estimations. Furthermore, these impacts are more significant in the bias-corrected DEA efficiencies.

Our observations with technical efficiency are similar to previous studies (Lieu, Yeh, & Chiu, 2005; Casu & Girardone, 2005; Pasiouras, 2008; Lozano-Vivas & Pasiouras, 2010) which argue that omitting off-balance sheet activities would underestimate bank technical efficiency. One possible reason for this observation is that banks can better utilise given resources and therefore increase their efficiency when conducting non-traditional activities (Lieu, Yeh, and Chiu, 2005). However, the decrease in scale efficiency from Model 1 (Model 3) to Model 2 (Model 4) suggests that involving non-traditional activities means banks are more likely to operate with various returns to scale.

Table 5- 8 Kruskal-Wallis Test Results for Efficiencies with and without OBS Activities

	Without Considering Risk		With Considering Risk	
	Model 1 Without OBS	Model 2 With OBS	Model 3 without OBS	Model 4 With OBS
Panel A: Bootstrap DEA Approach				
TE	chi-squared =6.426 probability =0.0112		chi-squared = 6.847 probability = 0.0089	
PTE	chi-squared =112.760 probability = 0.0001		chi-squared = 165.241 probability =0.0001	
SE	chi-squared = 10.380 probability = 0.0013		chi-squared = 4.106 probability = 0.0427	
Panel B: The Traditional DEA Approach				
TE	chi-squared = 11.130 probability = 0.0008		chi-squared = 11.881 probability = 0.0006	
PTE	chi-squared = 95.529 probability = 0.0001		chi-squared = 109.965 probability = 0.0001	
SE	chi-squared = 6.231 probability = 0.0126		chi-squared = 0.053 probability = 0.8175	

Notes: TE= overall technical efficiency; PTE = pure technical efficiency; SE = scale efficiency. Null hypotheses of the Kruskal-Wallis tests state that two efficiencies are the same and a small P-value suggests a rejection of the null hypothesis.

Source: Author's calculation.

For individual countries, Figure 5-2 displays the comparisons of PTE and SE[13] between Models 1 and 2, and Models 3 and 4, with the inclusion of off-balance sheet items as additional output. From Models 1 to 2, PTE increases and SE decreases for all of the sample countries. The comparison between efficiencies in Models 3 and 4 shows that PTEs are larger and SEs are smaller in Model 4 for most countries than those in Model 3. However, the Chinese and Indonesian banking industries show some differences when compared to other countries.

[13] Since the TE is the product of PTE and SE, we do not include TE in this part of our analysis for simplicity.

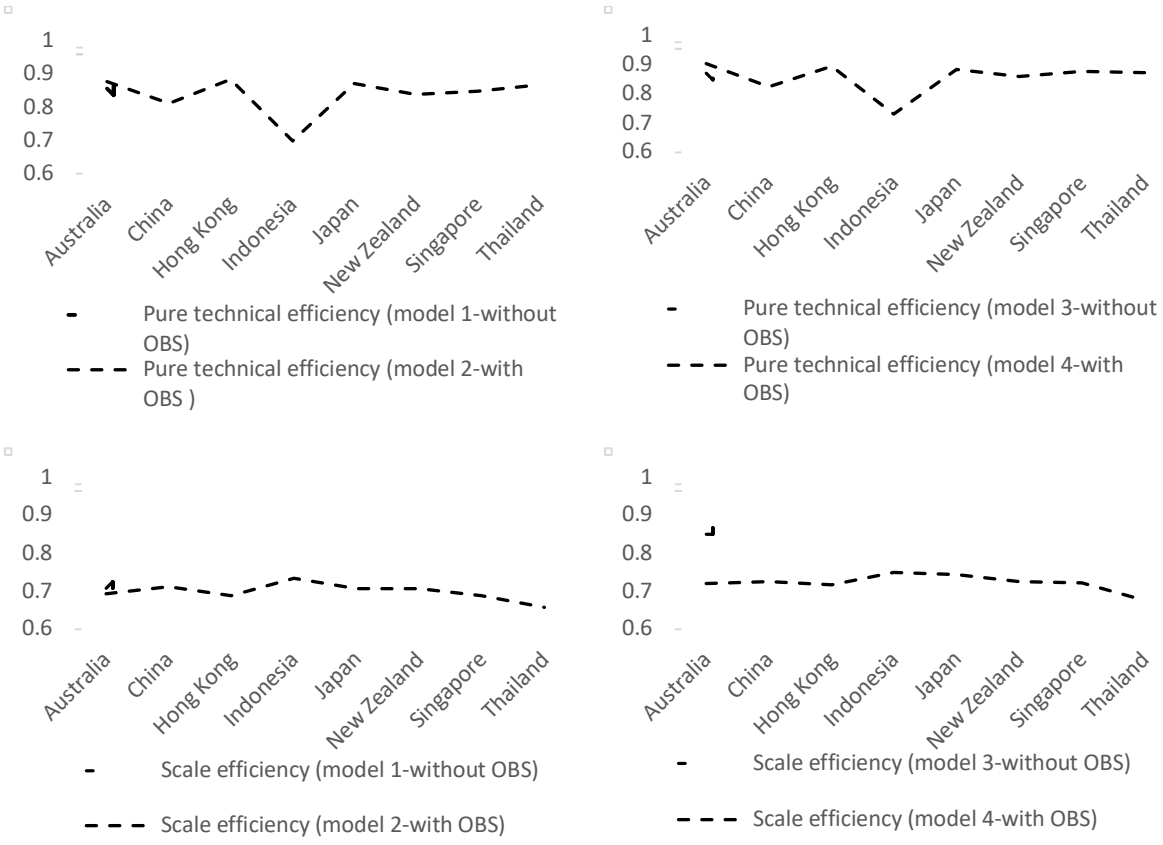


Figure 5-2 Comparisons of PTE and SE with and without Off-balance Sheet Items

Source: Author's calculations

Due to various development and risk status, non-traditional banking activities of each industry show different characteristics (see Figure 5-3). Using the ratio of off-balance sheet items over total assets and loan loss provisions over total loans, we observe that Thailand, Indonesia, and China exhibit higher loan loss provisions than the average value for all of the sample countries. Except for Japan (lowest) and Indonesia (highest), the off-balance sheet item ratios of each banking industries are quite close to the average value of the sample countries. These observations can explain differences in comparing the average PTE and SE of Chinese and Indonesian banks in Models 3 and 4. The inclusion of OBS items can increase PTE estimates and decrease SE estimates, but overuse of loan loss provisions can change the impact.

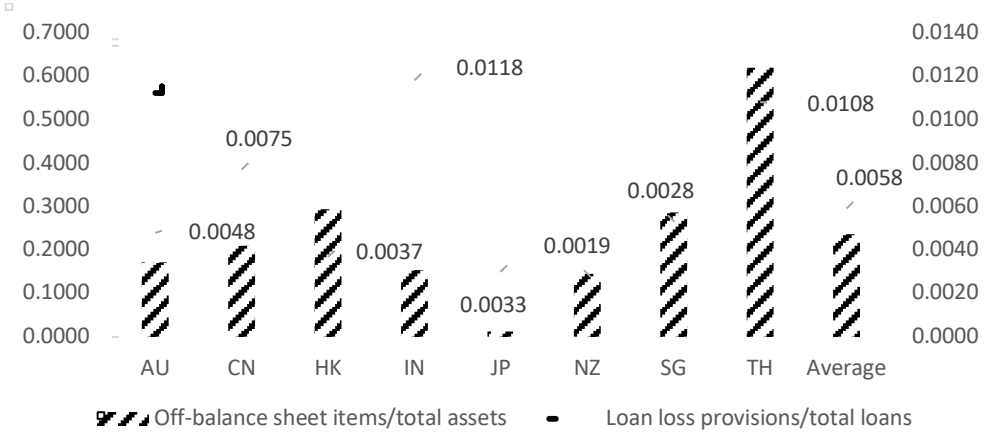


Figure 5-3 Loan Loss Provision Ratio and Off-balance Sheet Activity Ratio in Sample Countries (2005-2014)

Source: Author's calculations

For the four different models of efficiency estimations, we conduct a Skillings-Mack test to assess whether bank efficiencies estimated in the four different models (see Table 4-1) are statistically different and rank efficiencies for the four models. Table 5-9 indicates that efficiency estimates from the four models are significantly different, according to the small P-values for PTE (Panel A), TE (Panel B), and SE (Panel C). Furthermore, based on the information from the ranking statistics (WSumCRank and WSum/SE), we can confirm our observation in Table 5-8. Model 2 has higher PTEs and TEs than Model 1, and Model 4 has higher PTEs and TEs than model 3. In addition, after considering OBS activities, the SEs in Model 2 (Model 4) are lower than those in Model 1 (Model 3).

Table 5- 9 Results of Skillings-Mack Test for Efficiency Estimates for the 4 Models

	Number of Observations	WSumCRank	SE	WSum/SE
Panel A: Overall Technical Efficiency				
Model 1	2505	-3094.51	86.69	-35.7
Model 2	2505	-1266.47	86.69	-14.61
Model 3	2505	1326.88	86.69	15.31
Model 4	2505	3034.1	86.69	35
Skillings Mack =2210.210				
P-value (No ties) = 0.0000				
Panel B: Pure Technical Efficiency				
Model 1	2505	-3004.66	86.69	-34.66
Model 2	2505	502.71	86.69	5.8
Model 3	2505	-510.46	86.69	-5.89
Model 4	2505	3012.41	86.69	34.75
Skillings Mack = 1857.871				
P-value (No ties) = 0.0000				
Panel C: Scale Efficiency				
Model 1	2505	256.39	86.69	2.96
Model 2	2505	-1742.07	86.69	-20.1
Model 3	2505	948.88	86.69	10.95
Model 4	2505	536.8	86.69	6.19
Skillings Mack = 428.050				
P-value (No ties) = 0.0000				

Notes: WSumCRank is the weighted sum of centred ranks; SE: standard error of the test; WSum/SE is the weighted sum of cantered ranks divided by the standard error. Smaller WSumCRank or WSum/SE indicates a lower rank among the models.

Source: Author's calculations

5.3.2 Technical Efficiency, Pure Technical Efficiency, and Scale Efficiency

Using meta-frontier TE, PTE, and SE[14] estimates from Model 4, Table 5-10 provides the results of bank performance for country groups of different income levels, individual countries, various years, and different regulation and supervisory groups.

Panel A in Table 5-10 shows the overall average efficiency estimates for sample banks in the Asia-Pacific region. The overall TE, PTE, and SE estimates are 0.6224, 0.8579, and 0.7276, respectively. Compared to the most efficient banks in the Asia-Pacific region, a representative bank can reduce its inputs by 37.76%[15] to reach the possible optimal production on the frontier. More specifically, this input reduction can be decomposed into 14.21% improvement in production technology in

[14] Since group-frontier efficiencies do not provide comparable information, only meta-frontier efficiency estimates are discussed in this section. All efficiencies are bias-corrected efficiency unless specified by author.
[15] The inefficiency score can be expressed as 1 minus efficiency scores.

converting inputs into outputs and 27.24% improvement of the banks' ability to exploit optimal operation sizes. The average pure technical efficiency for the full sample is higher than the scale efficiency for all four models, suggesting that overall technical inefficiency is due mainly to scale inefficiency. Sufian and Habibulah (2010) and Adgei-Frimpiong et al. (2014) find similar results for the Thai and the New Zealand banking industry.

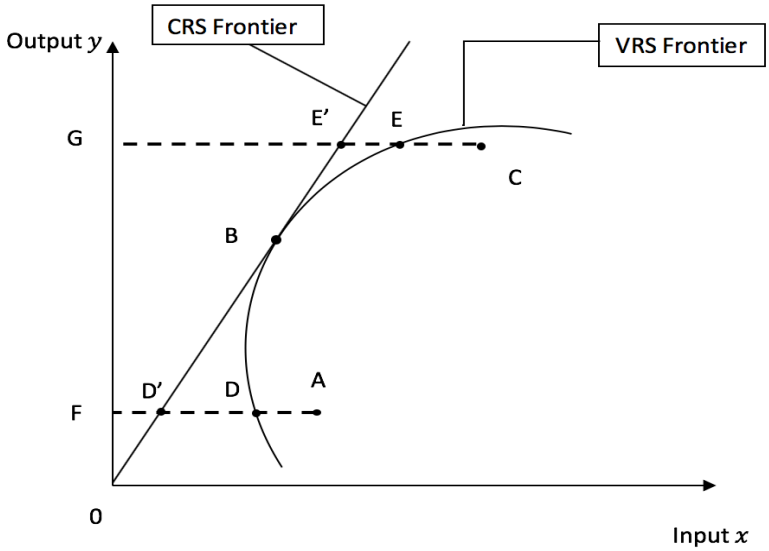


Figure 5-4 Simplified Illustration of Overall TE, PTE, SE for Banks in the Asia-Pacific Region

We use Figure 5-4 to illustrate efficiency scores through the simplified situation as explained in section 4.3, which assumes that banks only use one input to produce one output (for details see section 4.3). As shown in Figure 5-4, banks D, B, and E are all technically efficient, while banks D and E are pure technically efficient and bank B is overall technically efficient. Suppose a representative bank in Asia-Pacific operates on point C, the PTE can be represented by the $\frac{\mathrm{GE}}{\mathrm{GC}}(0.8579)$, indicating that bank C can move to E through reducing inputs by $\frac{EC}{GC}(0.1421)$ to be technically efficient. However, the production point E is at the various returns to scale stage. Therefore, bank C can move from production point E to production point E' by changing its scale of operation and further reducing its input amount from GE to GE' by $\frac{EE\prime}{GE}$ (0.2724). In other words, scale efficiency for the bank operating at point C is $\frac{GE\prime}{GE}$ $(0{,}7276)$. The overall TE of bank C can be represented by $\frac{GE\prime}{GC}$ (0.6224). In contrast, banks that operate at E and D have PTEs of 1 but TEs smaller than 1. Banks that operate at B have PTE=TE=1.

As explained by Fukuyama (1996), both production at point E and E' are optimal productions. However, a production stage of constant returns to scale indicates a long-run equilibrium in the competitive banking industry, suggesting that all banks operate at the optimal scale with a minimum

deadweight loss for society. Therefore, the efficient production point E is optimal for the bank manager, and the efficient production point E' is optimal for society as well as for the bank manager.

Following the World Bank's category of economies according to gross national income per capita,[16] Panel B in Table 5-10 shows the average PTE, TE, and SE scores for different economies. In our sample countries, Indonesia is a lower middle-income; China and Thailand are upper middle-income; Australia, Hong Kong, Japan, New Zealand, and Singapore are high-income economies. Banks operating in higher-income countries are more likely to have higher PTE and TE scores. Developed countries would typically have more experienced banking industries and thus more sophisticated production technologies. Additionally, demand for bank services and products could be higher in countries with higher incomes per capita. However, banks in the lower middle-income countries have the highest average SE estimates, while those from the upper middle-income countries have the lowest average SE scores.

The average efficiency for individual countries shown in Panel C in Table 5-10 indicates that bank efficiencies vary across countries. For example, Japanese banks have the highest overall technical efficiency score of 0.6609; Australian banks have the highest pure technical efficiency of 0.909; Indonesian banks have the highest average scale efficiency of 0.75 among the sample countries in the Asia-Pacific region. Even though Japanese banks' average PTE score (0.8603) is not as good as those of Australia (0.9039) and New Zealand (0.8603), the Japanese TE scores are the highest among the sample countries, attributed to the high SE scores of Japanese banks. In contrast, Indonesian banks' high scale efficiencies are offset by their low PTE. Therefore, banks in Indonesia exhibit the lowest overall technical efficiency. Similarly, the high PTE estimate in the Thai banking industry and low SE scores suggest that Thai banks operate with sophisticated production technology while they are not performing under the optimal size. The results of Thai banking industry are consistent with Sufian and Habibullah (2010)'s claim that Thai banks' scale inefficiency outweighs pure technical inefficiency.

Panel D in Table 5-10 and Figure 5-5 display the trend of efficiency scores for the sample banks in the Asia Pacific region from 2005 to 2014. Generally, the TE and SE scores exhibit similar patterns during the 10-year period. Both TE and SE estimates dropped dramatically in 2007 due to the 2008 GFC. After 2007, TE and SE estimates increase continuously to a higher level in 2010 and gradually decrease from 2011 to 2013. They then experience a slight increase in 2014. In contrast, the average PTE score has a steady declining trend from 2005 to 2014 with sharp decreases in 2008 and 2011. In

[16] According to the World Bank, low-income economies are defined as those with a gross national income (GNI) per capita of USD 1,005 or less in 2016; lower middle-income economies are those with a GNI per capita between USD 1,006 and USD 3,955; upper middle-income economies are those with a GNI per capita between USD 3,956 and USD12, 235; high-income economies are those with a GNI per capita of USD12, 236 or more.

general, all three types of bank efficiencies are lower in 2014 than in 2005, suggesting an overall decreasing trend during the 10-year period. The decrease in efficiency can be due to declining technological advancement of banks or improvements in the operating environment. In other words, banks may be less efficient relative to the same frontier, or banks operate using the same technology relative to an improved frontier, which lies further away from most banks (Gardener et al., 2011).

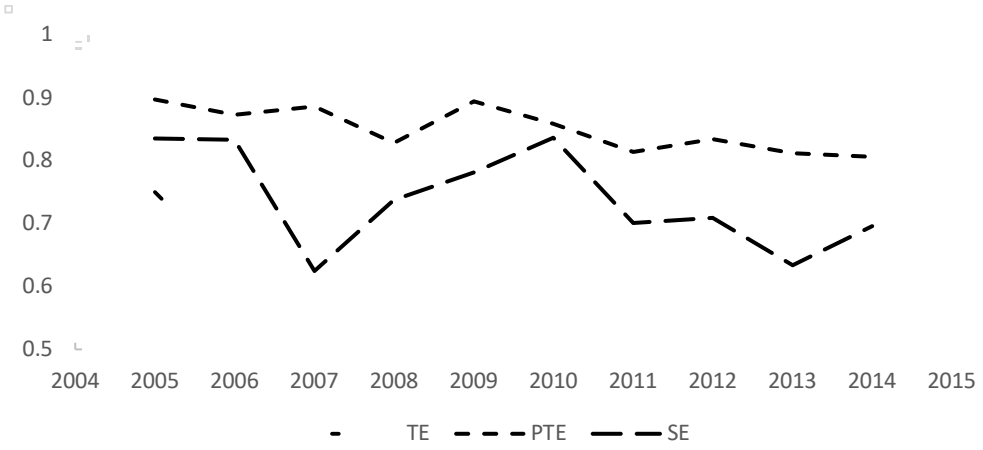


Figure 5- 5 TE, PTE, and SE Scores of Banks in the Asia-Pacific Region (2005 to 2014)

Source: Author's calculations

Panel E in Table 5-10 and Figure 5-6 compare the efficiencies of banks facing different regulation and supervision policies. For each regulation and supervision indicator, we divide the banks into two groups: banks facing stricter specific regulations or supervision policies are classified into one group and other banks into the remaining group. For example, based on the rank of the CAPITAL index, banks facing the highest 20%[17] capital regulation index is grouped as CAPITAL_1. Those banks facing the bottom 80% capital regulation index are classified as group CAPITAL_0. Similarly, banks are divided into two different groups according to the value of other regulatory and supervisory indicators.

On average, banks facing tighter capital regulation have slightly higher SE, lower TE, and lower PTE than banks with less strict capital regulation. Banks in the group of more powerful official supervision have higher average TE and SE, and lower PTE than other banks. Banks with stricter rules of information disclosure and activity restrictions have higher average PTE, lower TE, and lower SE than others. On average, tighter regulation and supervision tends to be correlated with a higher average

[17] In Lee and Lu (2015)'s study of international bank regulation and supervision, they use 30% as the threshold to divide banks into two groups for 53 countries around the world. Since we have only 8 sample countries (therefore the ranges of regulation and supervision indices are smaller), we choose 20% as the threshold so that we can observe differences between the groups.

pure technical efficiency. In Section 5.4 we explore the relationship between regulation, supervision and efficiency using the regression models.

Panel F in Table 5-10 shows the average TE, PTE, and SE estimates for state-owned banks and other types of banks. The average value of all three efficiency measurements of state-owned banks is lower than other banks. The relationship between state ownership and bank efficiency is examined in section 5.4.

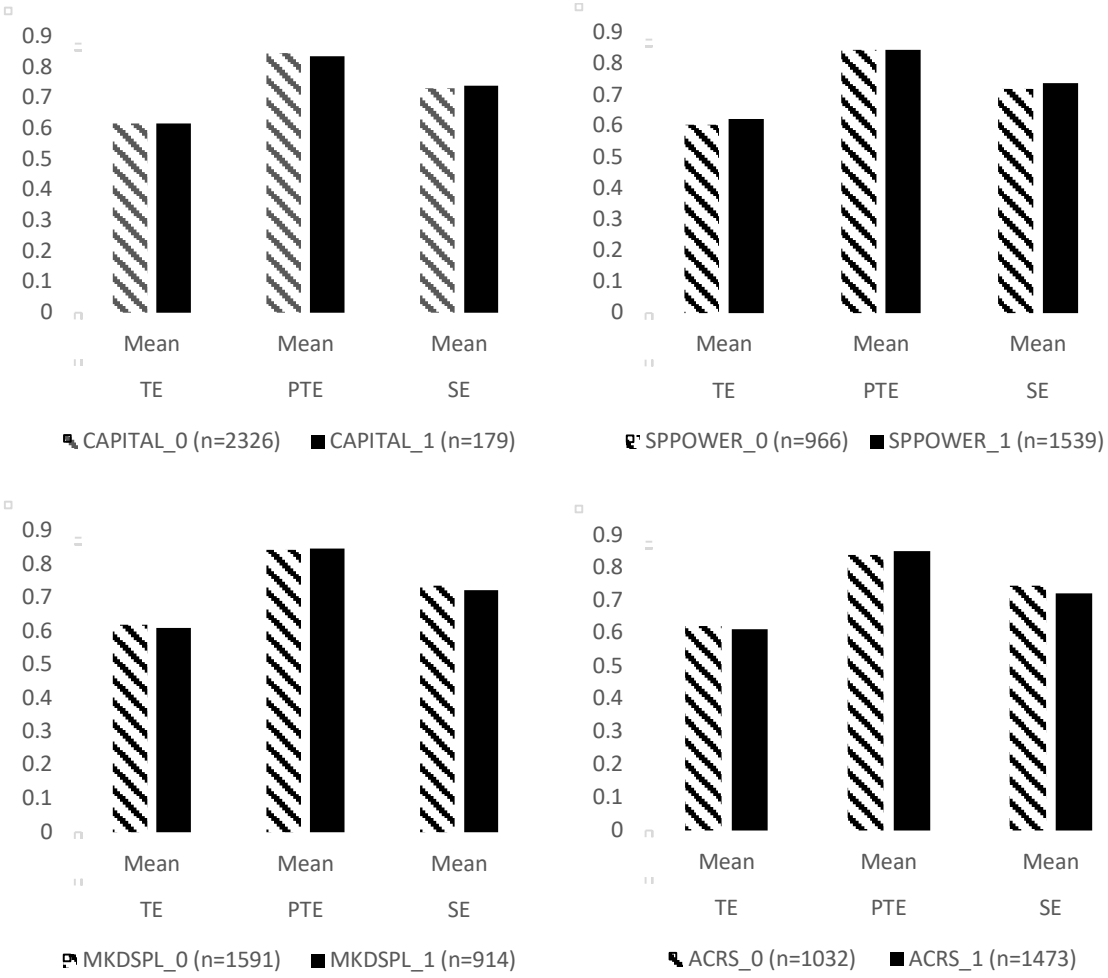


Figure 5-6 Comparisons of Overall Technical Efficiency, Pure Technical Efficiency, Scale Efficiency between Different Regulatory and Supervision Groups

Source: Author's calculations

Figure 5-7 Comparison of Overall Technical Efficiency, Pure Technical Efficiency, Scale Efficiency between State-owned Banks and Other Banks

Source: Author's calculations

Table 5-10 Summary of Technical Efficiency, Pure Technical Efficiency, and Scale Efficiency of Asia-Pacific Banking Industry

	Overall technical efficiency		Pure technical efficiency		Scale efficiency	
Panel A: Full Sample	Mean	SD	Mean	SD	Mean	SD
Full Sample(n=2505)	0.6224	0.1339	0.8579	0.1070	0.7276	0.1335
Panel B: Different Income Groups						
High Income (n=1211)	0.6523	0.12	0.8863	0.0772	0.737	0.1237
Upper Middle Income (n=786)	0.5937	0.1276	0.8344	0.1108	0.7152	0.1339
Lower Middle Income (n=389)	0.5437	0.159	0.7312	0.1564	0.75	0.1587
Panel C: Different Countries						
Australia (n=119)	0.6502	0.1327	0.9039	0.0791	0.7213	0.1397
China (n=627)	0.5946	0.1285	0.8245	0.1175	0.725	0.1323
Hong Kong (n=156)	0.6429	0.1131	0.8958	0.0665	0.7174	0.1107
Indonesia (n=389)	0.5437	0.159	0.7312	0.1564	0.75	0.1587
Japan (n=941)	0.6571	0.1164	0.8847	0.07	0.7438	0.1228
New Zealand (n=60)	0.6189	0.1415	0.8603	0.1443	0.7265	0.1364
Singapore (n=54)	0.6367	0.1405	0.877	0.102	0.7226	0.1163
Thailand (n=159)	0.5903	0.1239	0.8737	0.066	0.6763	0.1335
Panel D: Different Year Groups						
2005 (n=177)	0.7503	0.0929	0.8977	0.0615	0.8353	0.0798
2006 (n=203)	0.7277	0.1013	0.873	0.0809	0.8341	0.0906
2007 (n=209)	0.5491	0.0873	0.8866	0.097	0.6248	0.1061
2008 (n=213)	0.6087	0.1247	0.8287	0.1217	0.7381	0.1229
2009 (n=244)	0.6958	0.0798	0.8952	0.092	0.7812	0.085
2010 (n=268)	0.7164	0.0789	0.8592	0.0928	0.8368	0.0685
2011 (n=287)	0.562	0.1165	0.8142	0.1538	0.7012	0.1217
2012 (n=284)	0.5896	0.1307	0.8346	0.116	0.7096	0.1312
2013 (n=319)	0.5071	0.1068	0.8121	0.1332	0.6337	0.1263
2014 (n=302)	0.5604	0.1316	0.8065	0.1147	0.696	0.1316

Panel E: Different Regulation and Supervision Groups						
CAPITAL_0 (n=2326)	0.6170	0.1329	0.8466	0.1158	0.7316	0.1313
CAPITAL_1 (n=179)	0.6183	0.1648	0.8379	0.1354	0.7404	0.1587
SPPOWER_0 (n=966)	0.6061	0.1280	0.8457	0.1126	0.7200	0.1294
SPPOWER_1 (n=1539)	0.6239	0.1394	0.8461	0.1201	0.7398	0.1353
MKDSPL_0 (n=1591)	0.6208	0.1391	0.8447	0.1209	0.7376	0.1352
MKDSPL_1 (n=914)	0.6105	0.1285	0.8481	0.1108	0.7228	0.1296
ACRS_0 (n=1032)	0.6226	0.1429	0.8396	0.1326	0.7451	0.1351
ACRS_1 (n=1473)	0.6131	0.1298	0.8504	0.1050	0.7232	0.1315
Panel F: State Ownership Groups						
STATE=0	0.6277	0.1327	0.8608	0.1043	0.7311	0.1324
STATE=1	0.5729	0.1345	0.8308	0.1261	0.6945	0.1392

Notes: TE = overall technical efficiency; PTE= pure technical efficiency; SE = scale efficiency. CAPITAL_0 = banks with lower capital regulation; CAPITAL_1 = banks with higher capital regulation; SPPOWER_0 =bank group facing lower official supervision power; SPPOWER_1 = banks facing higher official supervision power. MKDSPL_0 = banks facing lower regulations relating to market discipline; MKDSPL_1 = bank group facing higher regulations relating to market discipline; ACRS_0 = bank group with less activity restrictions; ACRS_1 = bank group with more activity restrictions.

Source: Author's calculations

5.3.3 Group-frontier Efficiency, Meta-frontier Efficiency and Technology Gap Ratios

Since pure technical efficiency reflects the distance from the bank to the production frontiers (Hosseinzadeh et al., 2016), PTE estimates are used to calculate TGRs (technology gap ratios) rather than the overall TE estimates. Measuring the distances from the group-frontiers to the meta-frontier, a higher TGR score indicates that the banking industry has more sophisticated production technology. In other words, countries with higher TGR scores have better production technology than other countries. Table 5-11 displays the average value of group-frontier PTEs, meta-frontier PTEs, and the TGRs for the sample countries and different regulatory and supervisory groups from 2005 to 2014.

5.3.3.1 Efficiency Estimates for Individual Countries

Figure 5-8 shows the trends of the average group-frontier PTE and meta-frontier PTE estimates for each country over the study period. The group-frontier PTE scores are relatively high for all of the sample countries and range between 0.8598 (Indonesia) and 1 (Singapore). These figures suggest that an average Indonesian bank can reduce 14% of its input to be efficient given the production technology in Indonesia, while all Singaporean banks operate on the production frontier of Singapore. Compared to the group-frontier PTE, the meta-frontier PTE estimates for individual countries show more fluctuation during the 2008 GFC. Despite different trends, we can observe that the average meta-frontier PTE estimates in all eight countries declined in 2008.

Most Australian banks are technically efficient (group PTE estimates equal to 1) relative to the group frontier from 2005 to 2014. However, the average meta-frontier PTE shows a declining trend, especially after the 2008 financial crisis in the Australian banking industry. The group PTE and meta PTE of Chinese banks show similar patterns, which indicate that the average pure technical efficiency decreases from 2006 to 2008 and recovers from 2009 onwards. The group PTE and meta PTE of Chinese banks show similar trends over the study period. The Hong Kong banking industry efficiency declines in 2008, increases in 2009 and then decreases gradually until 2012. In 2013 and 2014, the average technical efficiency of Hong Kong banks increases. Different from other countries, bank efficiency in Indonesia exhibits more fluctuations during the 10-year period. There are two sharp declines in 2008 and 2011. Based on the trends of both groups and meta PTE, Japanese banks maintain high efficiency from 2005 to 2014. In 2006 and 2008, there are two slight decreases in the Japanese banking industry. Similar to other countries, New Zealand bank efficiencies decrease gradually over the period with two slumps in 2008 and 2011. Singapore banks have an overall decreasing trend from 2005 to 2014, with an increase in 2010. Before 2008, the Thai banking industry shows a declining trend in the pure technical efficiency, followed by a rise in 2009. From 2010, Thai bank efficiency declines continuously until 2014.

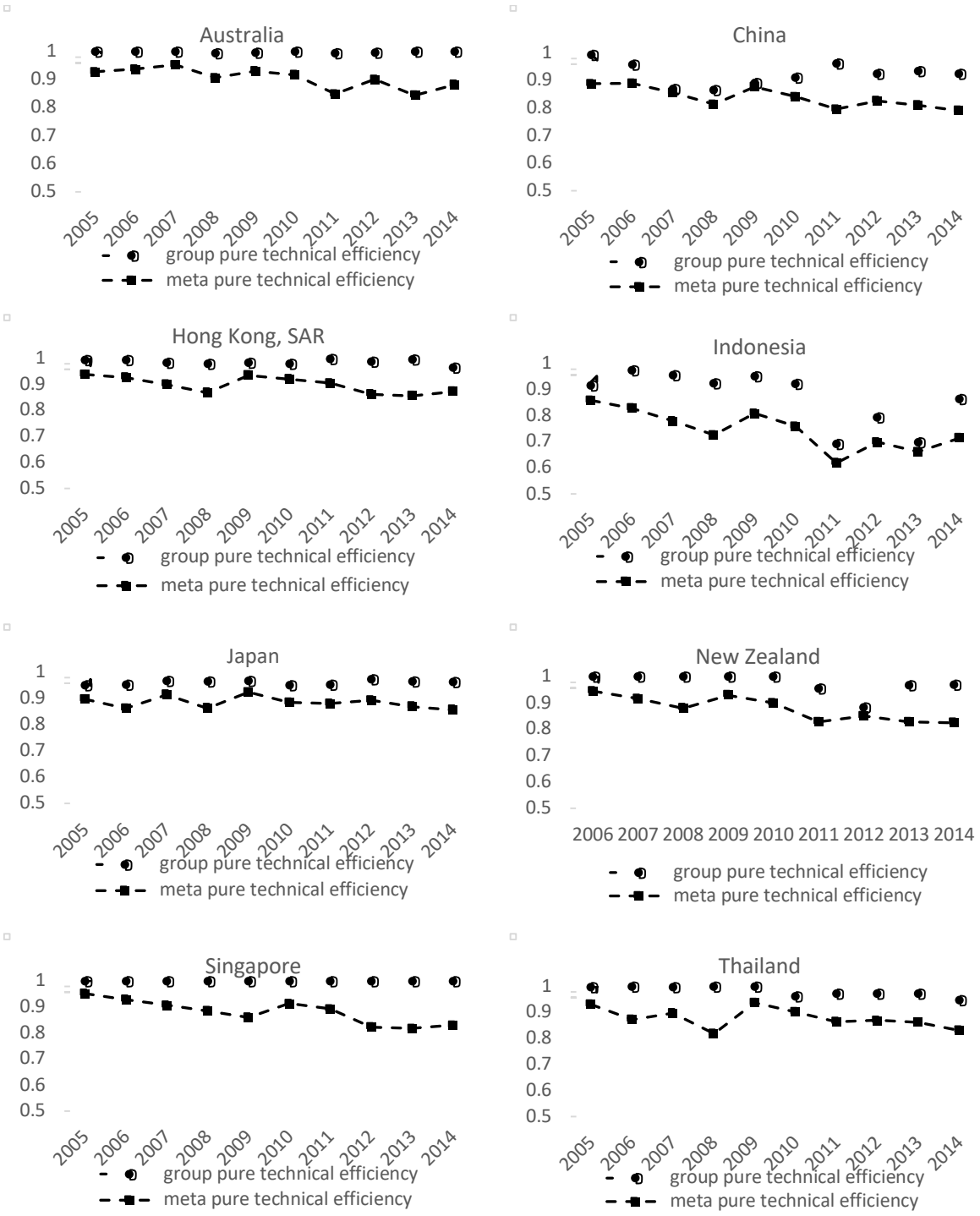


Figure 5- 8 Group-frontier and Meta-frontier PTE Estimates (2005 to 2014)

Source: Author's calculations

5.3.3.2 Comparison of Bank Efficiency among Countries in the Asia-Pacific Region

One important thing to note is that the group-frontier PTEs are not comparable across groups. For example, the average group PTE score (0.9582) of Japanese banks indicates that a representative bank in Japan can improve its production ability by reducing its inputs by 4.18% to be efficient in the Japanese banking industry. However, the average group PTE score (0.9775) of New Zealand banks

does not suggest that banks in New Zealand perform better than those in Japan. The high average group-frontier PTE in each country indicates that an average bank in one country is operating near the technology frontier in the same country.

Since all banks' efficiency are measured relative to the same frontier, meta-frontier PTE scores can provide more information about whether banks perform better than the other banks from different countries. Panel A in Table 5-11 shows the average meta-frontier PTE score of 0.9039 for Australian banks is the highest, relative to the average level of other countries, followed by Hong Kong (0.8958) and Japan (0.8847). In contrast, Indonesian banks have the lowest average meta-frontier PTE estimate of 0.7312, which suggests that an average bank in Indonesia can reduce inputs by 26.88% compared to the most efficient banks in the Asia-Pacific region, to produce the same level of outputs.

Combining the information of group-frontier PTE and meta-frontier PTE, the range of the TGR scores for the sample countries is from 0.8610 (Indonesia) to 0.9227 (Japan). Compared to the meta-frontier PTE, the relatively small range of TGRs suggest that the distances between the country-frontiers and meta-frontier are similar among the sample countries. For example, the average TGR for Australian banks of 0.9091 indicates that Australian banks operating on the frontier can improve and move towards the meta-frontier by reducing inputs by 9.09%.

We can take a representative bank C in Australia and a representative bank C' in Indonesia as examples and assume that two group-frontiers and meta-frontier are shown as in Figure 5-9. The meta-frontier PTE of bank C equals $\frac{GE}{GC} = 0.9039$; the group-frontier PTE of bank C equals $\frac{GD}{GC} = 0.9982$; the TGR of bank C equals $\frac{GE}{GD} = 0.9091$. For bank C' in Indonesia, the meta-frontier PTE is $\frac{G'E'}{G'C'} = 0.7312$; the group-frontier PTE is $\frac{G'D'}{G'C'} = 0.8529$; the TGR is $\frac{G'E'}{G'D'} = 0.8610$ (see Panel A in Table 5-11). A higher average value of TGRs of Australian banks suggests that the Australia group frontier lies closer to the met-frontier than the Indonesia frontier.

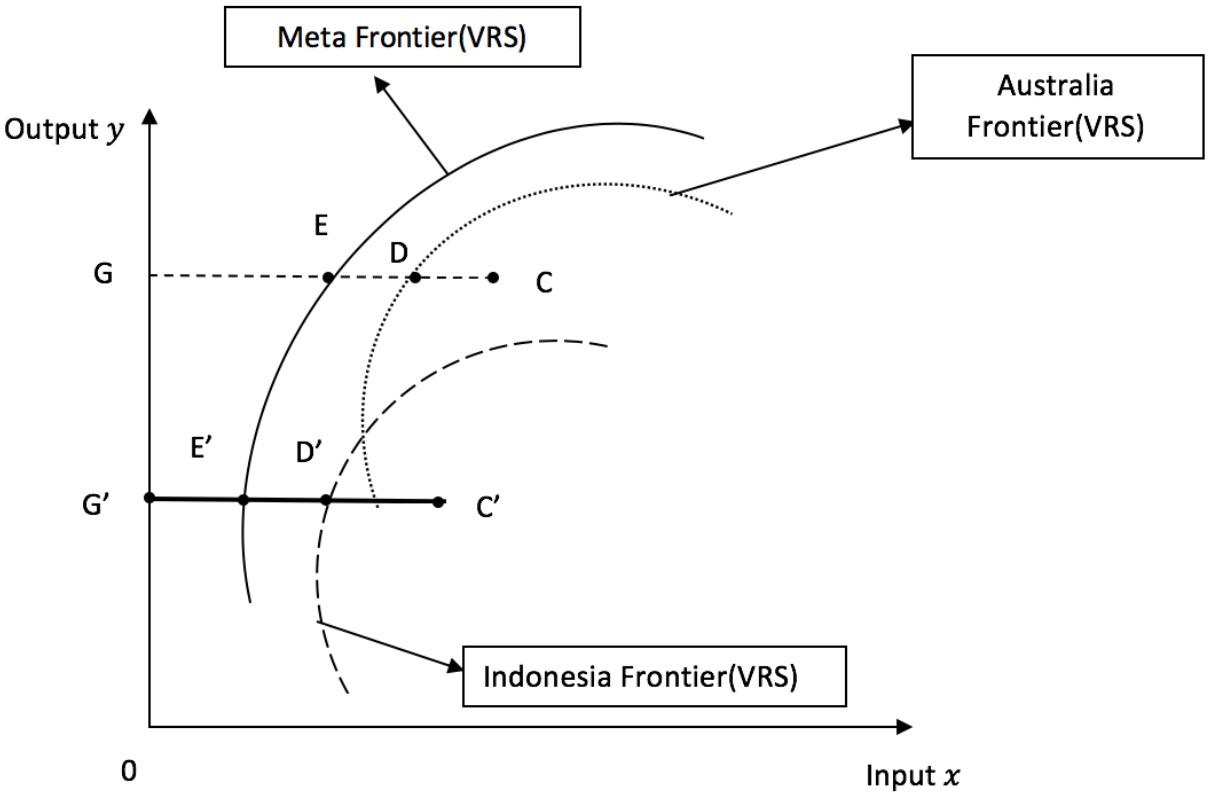


Figure 5- 9 Simplified Meta-frontier PTEs and Group-frontier PTEs and TGRs Illustration

Source: Author's calculations

Panel A in Table 5-11 and Figure 5-10 provide details of efficiency estimates for banks of different ownership types. According to the group-frontier PTE estimates, Chinese, Japanese, and New Zealand[18] state-owned banks perform better than domestic and foreign banks. When considering efficiency relative to the meta-frontier, Chinese, Japanese, and Thai state-owned banks are more efficient compared to banks of other ownership types. An important finding is that state-owned banks in New Zealand are more efficient than other banks using the group-frontier, while New Zealand foreign banks are most efficient relative to the meta-frontier. Changes in efficiency of different bank groups can be explained by the different shapes of the estimated frontiers using different dataset.

To capture the characteristics of regulation and supervision, Panel B in Table 5-11 and Figure 5-11 exhibit the average efficiency scores of banks under different regulation and supervisory groups. We observe that banks facing stricter capital regulation have higher group-frontier PTE, lower meta-frontier PTE and TGR scores. The banks under more official supervision power have higher average TGR scores, lower group PTE and TGR scores. With more market discipline and activity restrictions,

[18] According to the ownership data from Bankscope database and official websites of banks, Post Bank in Japan and Kiwibank in New Zealand are state-owned banks.

banks are more likely to have higher group PTE and meta PTE but lower TGR scores. Overall, the comparison suggests that banks facing tighter regulation and supervision tend to have higher meta-frontier and group-frontier PTE estimates. The TGRs results for different regulation and supervision groups are mixed.

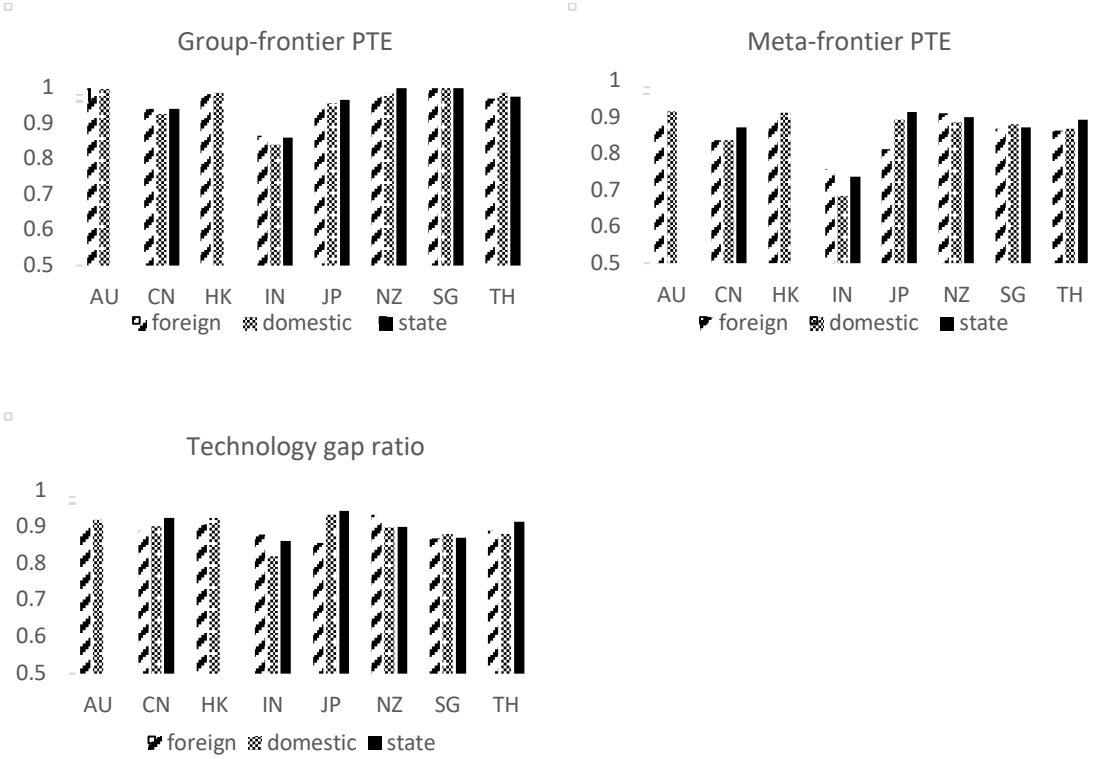
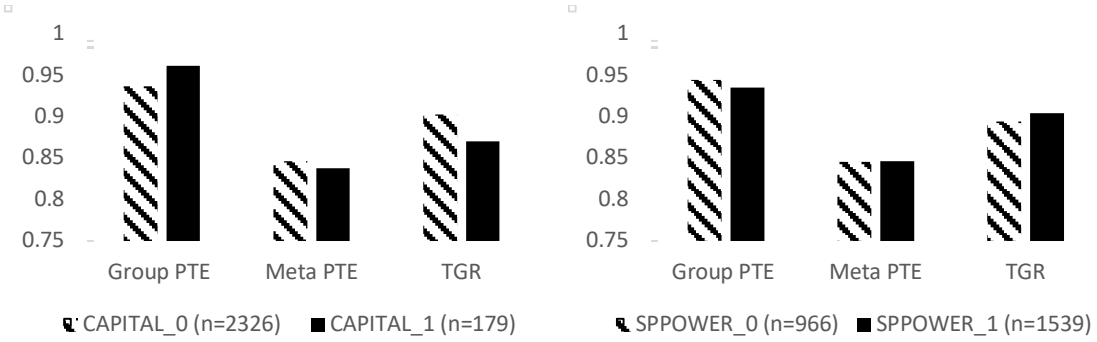


Figure 5-10 Average Group PTE, Meta PTE, and TGR for Each Country (2005 to 2014)

Source: Author's calculation



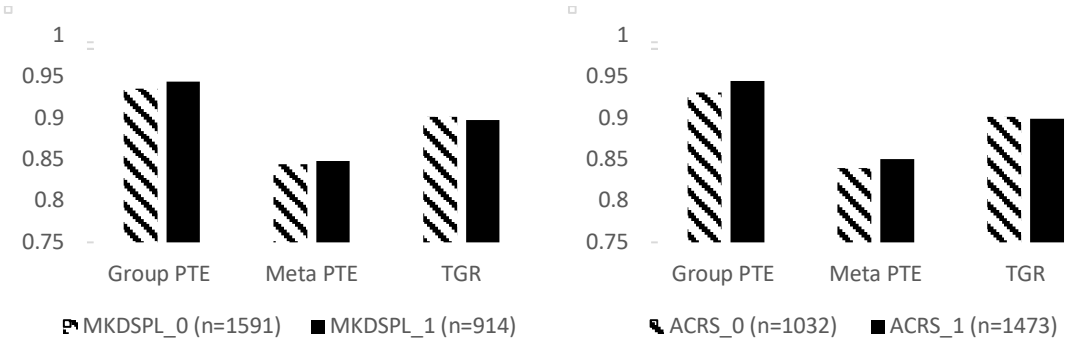


Figure 5- 11 Comparison of Average Group-frontier PTE, Meta-frontier PTE, and Technology Gap Ratios between Different Regulation and Supervision Groups

Source: Author's calculations

Table 5- 11 Group-frontier PTE, Meta-frontier PTE, and TGRs for Sample Countries (2005 to 2014)

	Group PTE		Meta PTE		TGR	
Panel A	Mean	SD	Mean	SD	Mean	SD
Australia (n=119)	0.9982	0.0154	0.9039	0.0791	0.9091	0.0828
Foreign	0.9988	0.0014	0.89	0.0644	0.8988	0.0781
Domestic	0.9979	0.0042	0.9156	0.0665	0.9197	0.0676
State	NA	NA	NA	NA	NA	NA
China (n=627)	0.9232	0.0524	0.8245	0.1175	0.8930	0.1060
Foreign	0.9411	0.0403	0.8363	0.1167	0.8892	0.122
Domestic	0.9271	0.0597	0.8367	0.0973	0.9021	0.0838
State	0.9423	0.0472	0.8717	0.0903	0.9245	0.0813
Hong Kong (n=156)	0.9843	0.0203	0.8958	0.0665	0.9099	0.0630
Foreign	0.9839	0.0214	0.893	0.0701	0.9074	0.0662
Domestic	0.987	0.0116	0.9129	0.0346	0.925	0.0357
State	NA	NA	NA	NA	NA	NA
Indonesia (n=389)	0.8529	0.1418	0.7312	0.1564	0.8610	0.1292
Foreign	0.8654	0.1374	0.7573	0.1442	0.8796	0.1192
Domestic	0.8404	0.1594	0.6845	0.1697	0.8194	0.14
State	0.8612	0.1366	0.7377	0.1463	0.8614	0.1276
Japan (n=941)	0.9588	0.0269	0.8847	0.07	0.9227	0.0688
Foreign	0.9483	0.057	0.813	0.1614	0.8568	0.1573
Domestic	0.9584	0.0261	0.8938	0.0577	0.9326	0.0544
State	0.9669	0	0.9135	0	0.9447	0
New Zealand (n=60)	0.9636	0.0272	0.8603	0.1443	0.8897	0.1266
Foreign	0.9752	0.0287	0.9103	0.0316	0.934	0.038
Domestic	0.9854	0.0137	0.8856	0.0356	0.8985	0.0278
State	1	0	0.9005	0.0264	0.9005	0.0264
Singapore (n=54)	1	0	0.877	0.102	0.8770	0.1020
Foreign	1	0	0.8691	0.0768	0.8691	0.0768
Domestic	1	0	0.8809	0.1145	0.8809	0.1145
State	1	0	0.8713	0.0468	0.8713	0.0468
Thailand (n=159)	0.9785	0.0284	0.8737	0.066	0.8929	0.0627
Foreign	0.9711	0.035	0.8637	0.0668	0.8895	0.0616
Domestic	0.9872	0.0174	0.8694	0.0709	0.8807	0.0716
State	0.9769	0.0267	0.8938	0.0523	0.9146	0.0392
Panel B						
CAPITAL_0 (n=2326)	0.9374	0.0835	0.8466	0.1158	0.9029	0.0924
CAPITAL_1 (n=179)	0.9622	0.0519	0.8379	0.1354	0.8705	0.1226
SPPOWER_0 (n=966)	0.9451	0.0668	0.8457	0.1126	0.8945	0.0991
SPPOWER_1 (n=1539)	0.9354	0.0898	0.8461	0.1201	0.9044	0.0925
MKDSPL_0 (n=1591)	0.9362	0.0894	0.8447	0.1209	0.9020	0.0944
MKDSPL_1 (n=914)	0.9444	0.0664	0.8481	0.1108	0.8981	0.0966
ACRS_0 (n=1032)	0.9309	0.1082	0.8396	0.1326	0.9020	0.0951
ACRS_1 (n=1473)	0.9449	0.0558	0.8504	0.1050	0.8996	0.0952

Notes: group PTE = group-frontier pure technology efficiency; meta PTE = meta-frontier pure technical efficiency; TGR = technology gap ratio.

Source: Author's calculations

5.4 Bootstrap Truncated Regression Results

5.4.1 Impact of Bank Regulation, Supervision, and Ownership on Bank Efficiency

To examine whether bank regulation, supervision, and state ownership in banks have a significant influence on bank performance, the second-stage bootstrap truncated regression model (Simar and Wilson, 2007) is employed in this study. Definitions and sources of the independent variables used in the bootstrap truncated regression models are presented in Table 4-8. Additionally, descriptive statistics relating to the variables are shown in Table 5-5. The pairwise correlation coefficients between the independent variables are presented in Appendix Table A-3. Based on the correlation matrix of the independent variables described in Section 4.4, the absolute values of most of the correlation coefficients are smaller than 0.3, and the maximum absolute value of the correlation coefficients is less than 0.7. Thus, multicollinearity should not be a major concern in our analysis using the bootstrap truncated regression models. Additionally, we use the robust standard error in all of the bootstrap truncated regression models to deal with potential heteroskedasticity problems. Year dummy and country dummy variables are included in the regression models to capture the impact of time and other unspecified country-specific characteristics.

Table 5-12 exhibits the regression results of the relationship between regulation, supervision and bank efficiencies (that is, PTE-pure technical efficiency, SE-scale efficiency and TGR-technology gap ratio) using the full sample of 2186 bank-year observations. As discussed in section 4.3.1, omitting off-balance sheet items and loan loss provision would underestimate bank efficiency. Therefore, efficiencies in Model 4 are our main discussion. Columns 1 to column 3 in Table 5-12 show the regression results using bias-corrected efficiencies from Model 4 as dependent variables. Since the efficiency estimated in Model 4 contains information about OBS activities and loan loss provision, we do not include the OBSTA and LLPTL in the regression models. For comparison, we include OBSTA and LLPTL in the regression models when using the efficiencies from Model 1 as the dependent variables. The regression results using Model 1 efficiencies are shown in columns 4 to column 6 in Table 5-12.

Overall, the regression results show that regulation and supervision policies are positively related to pure technical efficiency and technology gap ratio of banks in the Asia-Pacific region. As the first pillar of the Basel Accord, the capital requirement has a positive relationship with PTE and TGR at a 1% significance level. Consistent with previous empirical studies (Lozano-Vivas and Pasiouras, 2010; Barth et al., 2013, Luo et al., 2016), stricter capital requirements can reduce the incentive to engage in risky behaviour and therefore improve the bank performance. The positive relationship between capital regulation and scale efficiency is found to be insignificant.

Similar to the capital requirement, the second pillar of the Basel Accord (that is, the official supervision power), is positively related to both PTE and TGR at a 5% significance level. Under the "official supervision approach", greater official supervision is believed to increase credit flow to firms which are well-connected with banks (Levine, 2003) and enhance bank performance. Furthermore, a powerful official supervision regime can improve bank efficiency through increased competition in the banking industry (Barth et al., 2006). Empirically, our result is consistent with Pasiouras (2008) and Luo et al. (2016)'s findings on global banking industries. Hirtle et al. (2016) found similar results in the US banks. Official supervisory power is not significantly related to banks' scale efficiency.

The significantly positive coefficients of market discipline on PTE, SE, and TGR estimates support the "private monitoring approach" hypothesis, in which regulation and supervision policies promoting private monitoring in banks can induce better performance. By requiring banks to disclosing adequate information to the public, market discipline can encourage private sectors to monitor banks with lower information and transaction costs (Barth et al., 2006). Table 5-12 shows market discipline is the only regulation and supervision variable which is significantly (at a 5% significance level) related to the scale efficiency of banks in the Asia-Pacific region.

Banks with more activity restrictions tend to have higher performance, in both pure technical efficiency and technology gap ratios. These findings are in line with Barth et al. (2004)'s discussion that restricting banks engagement in security underwriting, insurance underwriting, and real estate investments would limit the conflicts of interest between stakeholders. Furthermore, narrowing the range of activities can reduce risky behaviours caused by moral hazard (Boyd et al., 1998) and positively affect bank performance. There is no evidence to suggest a significant relationship between activity restrictions and scale efficiency.

The existence of a deposit insurance scheme in each country has no significant relationship with bank performance according to our results. Additionally, state ownership is not significantly related to bank performance in the Asia-Pacific region, despite lower average efficiencies of state-owned banks, as shown in Figure 5-7.

Bank-specific characteristics are found to have significant relationships with bank efficiencies. For example, bank size is positively related to technical efficiency and technical gap ratio, indicating that larger banks have better management and technology in their production processes. However, bank scale efficiency tends to be lower for larger banks, possibly due to the fact that most banks in the Asia-Pacific region expanded too quickly and operated at decreasing returns to scale during the 10-year sample period.

Additionally, banks with higher capital ratios performed well in all three efficiency estimates. When banks hold more capital, managers tend to be more risk-reverse in terms of operation and therefore these banks would exhibit better performance. Our results are consistent with most of the previous studies in bank performance (see Demirguc-Kunt and Huizinga, 1999; Goddard et al., 2004; Sufian and Habibullah, 2010; Fiordelisi et al., 2011; Pessarossi and Weill, 2015).

The level of liquid assets (LIQTA) in banks has a negative relationship with technical efficiency and technical gap ratio, but no significant correlation with scale efficiency. One of the possible reasons of a higher level of liquid assets could be that banks would raise more liquid assets to reduce risks during times of uncertainty and unfavourable industry conditions (Radic et al., 2012). Thus, banks tend to have lower performance during this time. Moreover, liquid assets are believed to be less profitable than the illiquid assets and reduce investment opportunities for banks managers. The negative relationship between liquid ratio and technical gap ratio implies that holding more liquid assets would widen the distance from the group frontiers to the meta-frontier in the banking industry.

The coefficients of macroeconomic variables show that the GDP growth is not significantly related to bank performance, while a higher inflation rate has a positive relationship with scale efficiency and a negative impact on technology gap ratio. The concentration (HHI) of the banking industry appears unrelated to bank performance in the Asia-Pacific region. Furthermore, the negative coefficients of PrCrGDP indicate a negative relationship between private credit from banks to GDP and bank performance, suggesting that financial markets with more lending to private credit have relatively lower bank performance. The overall institutional environment of banks is shown to have no significant relationship with bank performance in the Asia-Pacific region.

The regression results, using efficiencies of Model 1, are similar to those of Model 4. However, capital regulation is not significantly related to bank efficiency estimated from Model 1, suggesting that omitting off-balance sheet activities in efficiency estimation would affect the second-stage regression. This finding is consistent with Lozano-Vivas and Pasiouras (2014)'s conclusion. Moreover, deposit insurance is significantly related to the scale efficiency of Model 1. The level of off-balance sheet activities and loan loss provisions are significantly related to scale efficiency only. A higher level of off-balance sheet activities would increase the scale efficiency, while using more loan loss provisions would be associated with lower scale efficiency. The relationships between OBS activities and loan loss provision emphasises the importance of considering these two factors in the efficiency estimations.

Table 5- 12 Bootstrap Truncated Regression Results: Full Sample

VARIABLES	Model 4			Model 1		
	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio
Regulation and Supervision						
CAPITAL	0.0413***	-0.0008	0.0414***	0.0143	-0.0051	0.0024
	(3.3049)	(-0.1182)	(2.7251)	(1.4627)	(-0.6653)	(0.2161)
SPPOWER	0.0112**	0.0052	0.0304***	0.0162***	-0.0027	0.0346***
	(2.2398)	(1.2695)	(4.3678)	(3.6520)	(-0.7370)	(5.8246)
MKDSPL	0.0934**	0.0802**	0.2591***	0.0797**	0.0811**	0.1682***
	(2.0006)	(2.1102)	(3.6960)	(2.0011)	(2.3647)	(2.7786)
ACRS	0.0252**	-0.0035	0.0536***	0.0180**	-0.0011	0.0281**
	(2.4088)	(-0.4291)	(3.2889)	(2.0262)	(-0.1505)	(1.9672)
DEP_INS	-0.0180	0.0119	-0.0015	0.0003	0.0502***	-0.0039
	(-0.7791)	(0.6636)	(-0.0447)	(0.0132)	(3.2407)	(-0.1462)
Bank Ownership						
STATE	-0.0146	0.0101	-0.0209	-0.0078	0.0024	-0.0130
	(-1.2922)	(1.1599)	(-1.3806)	(-0.8073)	(0.2894)	(-1.0847)
Bank-specific						
BANKSIZE	0.0387***	-0.0307***	0.0496***	0.0353***	-0.026***	0.0397***
	(13.1486)	(-18.0733)	(8.6720)	(16.1771)	(-16.1730)	(11.4585)
EQTA	0.5016***	0.1470***	0.5327***	0.4708***	0.1332***	0.4169***
	(7.7435)	(3.2061)	(5.9613)	(8.8300)	(2.7354)	(6.4345)
LIQTA	-0.1147***	0.0359	-0.1367**	-0.0752**	0.0044	-0.0435
	(-2.8748)	(1.3852)	(-2.3743)	(-2.1534)	(0.1807)	(-1.0027)
OBSTA				-0.0261	0.0113*	-0.0161
				(-1.2194)	(1.7808)	(-1.1607)
LLPTL				-0.1660	-1.568***	-0.4978
				(-0.4644)	(-4.4302)	(-1.2061)
Country-specific						
GDP_growth	0.0028	-0.0007	0.0034	0.0053***	0.0009	0.0110***

	(1.2052)	(-0.4408)	(0.9910)	(3.0187)	(0.6334)	(4.3530)
INF	0.0021	0.0040***	-0.0074***	0.0024**	0.0040***	-0.0059***
	(1.5009)	(3.1245)	(-3.2805)	(2.0932)	(3.3899)	(-3.5733)
HHI	0.1704	0.1153	-0.0530	0.0569	-0.0385	-0.1445
	(1.3020)	(1.3683)	(-0.3083)	(0.5487)	(-0.6604)	(-1.1137)
PrCrGDP	-0.0014***	-0.0000	-0.0016**	-0.0000	-0.0006**	0.0008*
	(-2.9624)	(-0.1594)	(-2.4151)	(-0.0459)	(-2.3849)	(1.8283)
INST_ENV	-0.0403	-0.0369	-0.0264	-0.066***	-0.0249	-0.0481
	(-1.3761)	(-1.5343)	(-0.6527)	(-2.7279)	(-1.1007)	(-1.4502)
Constant	(2.4733)	(0.7818)	(3.7280)	(2.5700)	(1.5091)	(2.3282)
	-0.3658	0.8555***	-1.7831***	-0.4160	0.8127***	-1.2376**
Sigma	(-0.9459)	(2.7512)	(-2.9241)	(-1.2686)	(2.9727)	(-2.3473)
	0.1028***	0.0996***	0.1154***	0.0925***	0.0892***	0.1055***
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports the coefficients of regulation and supervision variables, state ownership, and other control variables in the Simar and Wilson (2007) bootstrap truncated regression models. Z-statistics are shown in the parentheses. See Table 4-8 for definitions and information about the independent variables. *, **,*** indicates 10%, 5% and 1% levels of significance, respectively.

Source: Author's calculations

5.4.2 Regulation and Supervision and Bank Size

To determine if the impact of regulation and supervision on bank efficiency vary between banks with different sizes, we categorise the sample banks in each country for each year into three groups: large, medium, and small, based on bank's total assets. Table 5-13 shows the regression results of efficiency for each bank groups. Our findings in Table 5-13 suggest that stricter regulation and supervision policies are mostly positively related to small-sized banks, but not to medium- or large-sized banks. Consistent with results in Table 5-12, the coefficient of state ownership is not significant for banks of any size.

The first three columns in Table 5-13 compare the impact of regulation, supervision, and state ownership on pure technical efficiency for three size bank groups. Tighter capital regulation and market discipline are significantly related to higher pure technical efficiency of small banks at a 1% level of significance. At the 10% significance level, activity restriction is positively associated with the pure technical efficiency of small banks. While official supervisory power has no significant relationship with the technical efficiency of small and medium banks, it is positively related to large bank technical efficiency at a 5% significance level. None of the regulation or supervisory policies are significantly related to the pure technical efficiency of medium-sized banks.

Columns 4 to 6 in Table 5-13 summarise the regression results on scale efficiency for different-sized banks. The official supervision power and market discipline are significantly related to the scale efficiency of small banks. Additionally, market discipline is also positively related to large-sized banks' scale efficiency. There is no significant impact of bank regulation and supervision on medium-sized banks. Compared to the pure technical efficiency, scale efficiencies of banks are less affected by regulation and supervision. Deposit insurance scheme is positively related to the small-sized banks' scale efficiency at the 10% significance level.

The relationships of regulation and supervision and bank technology gap ratio are shown in columns 7 to 9 in Table 4-8. All four of the regulatory and supervisory indicators are positively related to the technology gap ratio of small banks. For large banks, official supervisory power is positively associated with the technology gap ratio. The medium-sized banks' technology gap ratios are not affected by any of the regulation and supervision indicators.

As for bank characteristics, the results show that a higher capital ratio is associated with higher performance for smaller banks and negatively related to scale efficiency for large banks. Our finding is similar to Berger and Bouwman's (2013) study who find that small banks benefit more from higher capital ratios than large banks. The negative relationship between liquidity ratios and bank pure technical efficiency and technology gap ratios are significant only for medium- and large-sized banks.

GDP growth is positively related to the PTE and TGR of small banks while negatively associated with the TGR scores of medium banks. The inflation rate exhibits a positive relationship with bank scale efficiency across the three groups. However, the inflation rate is negatively related to the TGR of medium and large-sized banks. Different from the results using the full sample, the institutional environment index has a positive impact on the pure technical efficiency and technology gap ratio of large banks, while it is negatively related to the scale efficiency of large banks.

The regression results can provide valuable information for policymakers and regulatory authorities in the Asia-Pacific region, as banks of different sizes are affected differently by regulation and supervision. While most regulation and supervision improve the efficiency of small banks, medium- and large-sized banks still suffer from administrative fees and other costs associated with bank regulation and supervision. There could be customised regulation and supervision for different banks, which would allow the banking industry to exploit benefits from the regulatory environment while minimising costs associated with these practices.

Table 5- 13 Bootstrap Truncated Regression Results: Different-sized Bank Groups

	(Columns 1-3) Pure Technical Efficiency			(Columns 4-6) Scale Efficiency			(Columns 7-9) Technology Gap Ratio		
VARIABLES	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Regulation and Supervision									
CAPITAL	0.0757***	0.0171	0.0045	0.0202	-0.0067	-0.0185	0.0839**	0.0172	-0.0052
	(2.9635)	(1.0773)	(0.4986)	(1.1485)	(-0.3498)	(-1.1844)	(2.4592)	(0.8045)	(-0.3606)
SPPOWER	0.0100	0.0011	0.0081**	0.0310***	-0.0019	-0.0014	0.0301**	0.0115	0.0186***
	(0.9637)	(0.1682)	(2.1796)	(2.9870)	(-0.2548)	(-0.3157)	(2.0693)	(1.4927)	(3.9669)
MKDSPL	0.2654***	-0.0521	-0.0582	0.1474*	0.0507	0.1194**	0.5115***	-0.0102	0.0492
	(2.6430)	(-0.7393)	(-1.3764)	(1.8145)	(0.6432)	(2.0539)	(3.0413)	(-0.1138)	(1.0305)
ACRS	0.0398*	-0.0010	0.0053	0.0229	-0.0230	0.0039	0.0711*	0.0124	0.0150
	(1.8009)	(-0.0700)	(0.6782)	(1.3651)	(-1.3770)	(0.3400)	(1.9474)	(0.6400)	(1.4497)
DEP_INS	-0.0671	-0.0296	-0.0042	0.0676*	-0.0079	-0.0093	-0.0989	-0.0052	0.0157
	(-1.2391)	(-0.8829)	(-0.2506)	(1.6483)	(-0.2217)	(-0.4429)	(-1.2326)	(-0.1297)	(0.7598)
Ownership									
STATE	0.0194	-0.0185	0.0106	0.0259	0.0139	-0.0105	0.0077	0.0011	0.0073
	(0.6326)	(-1.1080)	(1.3256)	(0.9567)	(0.6755)	(-1.3329)	(0.1578)	(0.0628)	(0.9588)
Bank-specific									
EQTA	0.3548***	0.0093	0.1332	0.2146***	0.1388	-0.5144**	0.3188***	-0.0429	-0.2266
	(4.3773)	(0.0592)	(0.6794)	(3.7184)	(1.2648)	(-2.3111)	(2.9380)	(-0.2479)	(-1.1389)
LIQTA	-0.0703	-0.1182**	-0.1880***	0.0058	0.0468	-0.0002	-0.1221	-0.2056***	-0.1114**
	(-0.9504)	(-2.0130)	(-3.6610)	(0.1367)	(0.8438)	(-0.0052)	(-1.1268)	(-2.8275)	(-2.4968)
Country-specific									
GDP_growth	0.0117**	-0.0041	-0.0006	-0.0060*	0.0004	0.0021	0.0234***	-0.0068**	-0.0031
	(2.2114)	(-1.4506)	(-0.3212)	(-1.6692)	(0.1465)	(1.1888)	(2.8115)	(-2.1655)	(-1.4766)
INF	0.0019	0.0032*	-0.0005	0.0059**	0.0070***	0.0038**	-0.0071	-0.0100***	-0.0030**
	(0.6360)	(1.6664)	(-0.3732)	(2.2244)	(3.0186)	(2.3868)	(-1.4969)	(-4.1489)	(-2.2244)
HHI	0.0844	0.2166	0.0134	0.3355	0.2716	-0.1003	0.0661	-0.2207	-0.2000***
	(0.2927)	(1.4563)	(0.1662)	(1.3775)	(1.4077)	(-1.2404)	(0.1283)	(-1.4719)	(-2.7198)
PrCrGDP	-0.0005	-0.0013**	-0.0007*	0.0002	-0.0005	-0.0009**	-0.0004	-0.0015**	-0.0004

	(-0.4741)	(-2.4554)	(-1.7261)	(0.2486)	(-0.9370)	(-2.4464)	(-0.2328)	(-2.3008)	(-1.0400)
INST_ENV	-0.1690***	-0.0534	0.0559*	0.0351	-0.0643	-0.0944***	-0.2765***	0.0462	0.0597**
	(-2.7521)	(-1.1384)	(1.9522)	(0.6148)	(-1.3926)	(-3.4470)	(-3.2453)	(0.8689)	(2.3521)
Constant	-0.7725	1.5390***	1.2107***	-0.7807	0.7517	0.4405	-2.3958*	1.1413	0.4574
	(-0.9831)	(2.9823)	(4.0531)	(-1.1678)	(1.2258)	(1.0432)	(-1.7966)	(1.6180)	(1.2343)
sigma	0.1270***	0.0885***	0.0558***	0.1095***	0.0995***	0.0699***	0.1480***	0.0868***	0.0501***
	(19.2102)	(16.7169)	(11.2685)	(25.7747)	(30.6333)	(25.7247)	(12.9352)	(11.7518)	(17.0131)
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports the bootstrap truncated regression results in different-sized bank groups. Z-statistics are shown in parentheses. The pure technical efficiency, scale efficiency, and technology gap ratio scores are estimated in Model 4. See Table 4-8 for definitions and information on the independent variables. *, **,*** indicates 10%, 5% and 1% levels of significance, respectively.

Source: Author's calculations

5.4.3 Regulation, Supervision and Financial Crisis

After dividing our study period into two sub-period, another regression analysis is conducted to determine if bank regulation and supervision affect bank performance differently during various time periods. Table 5-14 displays the regression results for the period of 2005-2008 and 2009-2014. The regression results in the first study period capture the impact of regulation and supervision before and during the 2008 GFC, and the regression results during the second period measure the effects of regulation and supervision on bank performance after the 2008 GFC. Columns 1 and 2 in Table 5-14 show the results of pure technical efficiency; columns 3 to column 4 compare the results of scale efficiency; columns 5 to column 6 display the results of technology gap ratio. Our results reveal that regulation and supervision impact bank performance differently during the two study periods.

Regulation and supervision show a significant adverse impact on bank efficiency in the first study period from 2005 to 2008. More specifically, capital regulation, market discipline, activity restrictions, and deposit insurance are negatively related to pure technical efficiency. Higher supervision power from regulatory authorities is found to be associated with higher technical efficiency estimates from 2005 to 2008. In the second period, none of the regulatory and supervisory indexes is significantly related to the pure technical efficiency of banks.

From 2005 to 2008, regulation and supervision are not significantly related to scale efficiency of banks in the Asia-Pacific region. After the 2008 GFC, bank regulation and supervision are mostly negatively related to scale efficiency. Capital regulation has shown a significant positive relationship with scale efficiency at the 1% significance level. The coefficients of official supervision power, market discipline, activity restrictions, and deposit insurance are significantly negative.

From the information shown in Columns 5 to 6 in Table 5-14, regulation and supervision affect the bank technology gap ratio in a similar way as pure technical efficiency in the first study period. After the financial crisis, capital regulation exhibits a negative relationship, and official supervisory power exhibits a positive impact on technology gap ratios. However, the insignificant relationship between market discipline and technology gap ratio is significantly positive after the financial crisis. The previous negative relationships between activity restriction and deposit insurance with the technology gap ratio become positive in the second study period.

Similar to results from the previous analysis, state ownership is not significantly related to bank performance in any of these two study periods in the Asia-Pacific region.

Most of the coefficients of bank-specific characteristics remain the same as in the bootstrap truncated regression results using the full sample. The negative relationship between liquid asset

ratio and pure technical efficiency/technology gap ratio are significant after the financial crisis. However, the positive correlation between the liquid asset ratio and scale efficiency is only significant in the first study period.

Regarding country-specific characteristics, GDP growth is not significantly associated with bank performance throughout the two study periods. Inflation is positively related to bank technical efficiency for both periods. Nonetheless, from 2005 to 2008, inflation is negatively related to scale efficiency and positively associated with technology gap ratio. These relationships with scale efficiency and technology gap ratio reverse in the second period, following the 2008 GFC. The reverse relationship can also be found in the concentration ratio, private credit to GDP ratio, governance indicators and technical efficiency and scale efficiency relationships.

Our regression results provide interesting evidence about the relationship between regulation, supervision, and bank efficiency over different study periods. In the first study period, regulation and supervision are mostly negatively related to technical efficiency and technology gap ratio, suggesting the negative impact of regulation on bank performance before and during the financial crisis. However, tighter regulation and supervision narrowed the gap between group frontiers and meta-frontier after the financial crisis. Therefore, regulatory authorities could take advantage of the positive impact of regulation and supervision on technology gap ratio and update related regulatory rules to improve technology in the banking industry.

Table 5-14 Bootstrap Truncated Regression Results: 2005 to 2008 and 2009 to 2014

	Columns 1-2 Pure Technical Efficiency		Columns 3-4 Scale Efficiency		Columns 5-6 Technology Gap Ratio	
VARIABLES	2005-2008	2009-2014	2005-2008	2009-2014	2005-2008	2009-2014
Regulation and Supervision						
CAPITAL	-0.0562**	-1.3852	0.0081	2.7643***	-0.1181***	-3.0128**
	(-2.3783)	(-1.4684)	(0.3801)	(3.5619)	(-3.3864)	(-2.5016)
SPPOWER	0.1599***	0.1377	-0.0373	-0.4161***	0.2040***	0.2386*
	(4.9169)	(1.3350)	(-1.3759)	(-4.6252)	(4.3341)	(1.8397)
MKDSPL	-0.1128*	0.4881	0.0907	-1.0812***	0.0053	1.0136**
	(-1.8151)	(1.4601)	(1.6429)	(-3.8368)	(0.0569)	(2.3862)
ACRS	-0.1647***	0.1519	0.0284	-0.3313***	-0.2585***	0.4423**
	(-3.9709)	(1.0781)	(0.8321)	(-2.8566)	(-4.2291)	(2.4359)
DEP_INS	-0.0678***	0.3391	0.0153	-0.4444*	-0.0637**	1.0712**
	(-2.9316)	(0.9523)	(0.7613)	(-1.7806)	(-2.0232)	(2.3258)
Ownership						
STATE	-0.0230	-0.0137	0.0198	0.0066	-0.0376	-0.0194
	(-1.0283)	(-1.0794)	(1.2939)	(0.6156)	(-1.0613)	(-1.1859)
Bank-specific						
BANKSIZE	0.0429***	0.0355***	-0.0297***	-0.0310***	0.0626***	0.0406***
	(8.4305)	(10.0411)	(-10.7743)	(-14.5636)	(6.8552)	(6.5106)
EQTA	0.5314***	0.4400***	0.1556**	0.1591***	0.7127***	0.3181***
	(5.7197)	(5.1127)	(1.9967)	(2.5773)	(5.0107)	(3.1523)
LIQTA	-0.0151	-0.1329***	0.0716*	-0.0025	-0.0290	-0.1296*
	(-0.2392)	(-2.6495)	(1.6870)	(-0.0771)	(-0.3340)	(-1.8687)
Country-specific						
GDP_growth	0.0027	0.0024	-0.0033	-0.0012	-0.0009	-0.0037
	(0.4492)	(0.9121)	(-0.6533)	(-0.6740)	(-0.1051)	(-1.0090)
INF	0.0096**	0.0036**	-0.0073*	0.0035**	0.0158**	-0.0118***
	(2.0713)	(2.1407)	(-1.7396)	(2.3494)	(2.4208)	(-4.3425)
HHI	0.1889*	-0.6860**	-0.0896	0.9187***	-0.0296	-0.2718
	(1.8756)	(-2.4642)	(-1.1133)	(3.9101)	(-0.1714)	(-0.7486)

PrCrGDP	0.0085***	-0.0026***	-0.0046**	0.0009**	0.0019	-0.0013
	(3.7504)	(-3.0050)	(-2.5355)	(2.2874)	(0.5164)	(-1.2555)
institutional_env	-0.1565***	0.0816	0.0589*	-0.1904***	-0.1977***	0.1314*
	(-4.1846)	(1.5087)	(1.8975)	(-4.0968)	(-3.6885)	(1.9486)
Constant	-0.3910*	1.9721***	1.4806***	0.9918***	-0.1491	3.0060***
	(-1.8274)	(2.6777)	(8.9307)	(2.7436)	(-0.4826)	(3.2796)
Sigma	0.0861***	0.1073***	0.0891***	0.1023***	0.1033***	0.1143***
	(14.2127)	(25.2327)	(25.7761)	(44.8575)	(11.2181)	(14.9046)
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	No	No	No	No	No	No

Notes: This table reports the bootstrap truncated regression results in two different study periods: 2005-2008 and 2009-2014. Z-statistics are shown in the parentheses. Pure technical efficiency, scale efficiency, and technology gap ratio scores are estimated in Model 4. See Table 4-8 for definitions and information about the independent variables. *, **, *** indicates 10%, 5% and 1% levels of significance, respectively.

Source: Author's calculations

5.5 Robustness Check

5.5.1 Robustness Check: State Ownership

As discussed in Chapter 4, we categorise banks as state-owned if the central or local government owns more than 20% of a bank's shares. All of the results from the previous regression analysis in Section 5.4 have shown that state ownership is not significantly related to bank performance in the Asia-Pacific region. To verify if these results would change when using a different threshold, we use 30%[19] to define ownership type and conduct bootstrap truncated regression using the new state ownership variable. Table 5-15 shows the coefficients of the regressions show no significant changes after using the new ownership variable. Even though state ownership has negative coefficients on bank technical efficiency and technology gap ratio, the relationships are not significant. Additionally, the positive coefficient of state ownership on scale efficient is not significant based on the Z-values.

Regarding the regulation and supervision results, there is no significant difference between those in Table 5-12 and Table 5-15. The sign of the coefficients of each regulation and supervision remain the same as those in Table 5-12. The results confirm our findings from the previous section, that overall regulation and supervision have a positive impact on both bank technical efficiency and technology gap ratio. Market discipline is positively related to scale efficiency at a 10% significance level. Deposit insurance is not significantly related to bank performance in the Asia-Pacific region.

When efficiency estimates from Model 1 are used as dependent variables, capital regulation is not related to any of the three efficiency measures. Official supervisory power, market discipline, and activity restrictions have positive relationships with technical efficiency and technology gap ratios. Market discipline and deposit insurance are positively related to bank scale efficiency. All of the results of bank-specific and country-specific variables are consistent with the previous analysis.

[19] Following La Porta (2002) and Berger et al. (2005), we use 20% ownership as threshold to define the ownership. However, some studies (see for example, Micco et al. (2007), Lensink et al. (2008)) use 50% as threshold to define the ownership type. We use 30% as a middle range to conduct the robustness analysis.

Table 5-15 Bootstrap Truncated Regression Results for State Ownership of More than 30%

VARIABLES	Model 4			Model 1		
	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio
Regulation and Supervision						
CAPITAL	0.0419***	-0.0010	0.0415***	0.0145	-0.0050	0.0021
	(3.3454)	(-0.1396)	(2.7049)	(1.4788)	(-0.6351)	(0.1898)
SPPOWER	0.0108**	0.0058	0.0304***	0.0163***	-0.0024	0.0347***
	(2.1828)	(1.3184)	(4.2250)	(3.5323)	(-0.5938)	(5.4961)
MKDSPL	0.0970**	0.0798**	0.2726***	0.0846**	0.0810**	0.1775***
	(2.0504)	(2.1022)	(3.7239)	(1.9954)	(2.3381)	(2.8855)
ACRS	0.0256**	-0.0037	0.0554***	0.0188**	-0.0011	0.0293**
	(2.4190)	(-0.4532)	(3.2600)	(2.0572)	(-0.1503)	(2.0568)
DEP_INS	-0.0213	0.0149	-0.0058	-0.0014	0.0524***	-0.0068
	(-0.9195)	(0.8028)	(-0.1741)	(-0.0726)	(3.2541)	(-0.2583)
Ownership						
STATE	-0.0128	0.0072	-0.0181	-0.0073	0.0004	-0.0145
	(-1.0717)	(0.7560)	(-1.0348)	(-0.6711)	(0.0426)	(-1.0628)
Bank-specific						
BANKSIZE	0.0380***	-0.0307***	0.0493***	0.0351***	-0.0264***	0.0399***
	(12.6362)	(-18.1218)	(8.5229)	(15.7947)	(-16.0940)	(11.0808)
EQTA	0.4991***	0.1381***	0.5315***	0.4702***	0.1329***	0.4145***
	(7.6630)	(2.9787)	(5.7637)	(9.2028)	(2.8097)	(6.6512)
LIQTA	-0.1123***	0.0325	-0.1289**	-0.0733**	0.0005	-0.0355
	(-2.8923)	(1.2333)	(-2.1958)	(-2.1259)	(0.0188)	(-0.8047)
OBS				-0.0266	0.0114*	-0.0170
				(-1.1970)	(1.8324)	(-1.1945)
LLPTL				-0.1461	-1.5449***	-0.4313
				(-0.4142)	(-4.3973)	(-1.0458)
Country-specific						
GDP_growth	0.0030	-0.0010	0.0035	0.0053***	0.0006	0.0110***
	(1.2493)	(-0.6167)	(0.9690)	(3.0831)	(0.4426)	(4.2307)

INF	0.0018	0.0041***	-0.0075***	0.0023*	0.0042***	-0.0059***
	(1.2896)	(3.2010)	(-3.4064)	(1.9379)	(3.4715)	(-3.4896)
HHI	0.1474	0.1252	-0.0761	0.0500	-0.0358	-0.1491
	(1.1705)	(1.4866)	(-0.4471)	(0.4793)	(-0.6103)	(-1.1399)
PrCrGDP	-0.0015***	-0.0000	-0.0016**	-0.0000	-0.0006**	0.0008*
	(-3.0195)	(-0.1131)	(-2.3949)	(-0.0539)	(-2.3514)	(1.7891)
institutional_env	-0.0408	-0.0381	-0.0317	-0.0667***	-0.0212	-0.0533
	(-1.3597)	(-1.5327)	(-0.7541)	(-2.6095)	(-0.9227)	(-1.5375)
Constant	-0.3666	0.8465***	-1.8544***	-0.4431	0.7988***	-1.2938**
	(-0.9563)	(2.6915)	(-2.8871)	(-1.2660)	(2.8347)	(-2.4133)
Sigma	0.1021***	0.1000***	0.1151***	0.0925***	0.0895***	0.1053***
	(26.9147)	(52.4092)	(17.5320)	(33.5965)	(43.2281)	(23.2798)
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports the bootstrap truncated regression results using the state ownership variable created using the 30% threshold. Z-statistics are shown in the parentheses. Pure technical efficiency, scale efficiency, and technology gap ratio scores are estimated in Model 4. See Table 4-8 for definitions and information about the independent variables. *, **, *** indicates 10%, 5% and 1% levels of significance, respectively.

Source: Author's calculations

5.5.2 Robustness Check: Fractional Logit Regression and Tobit Regression

In Section 5.4, we employed the Simar and Wilson (2007)'s bootstrap truncated regression model to examine the relationship between bank regulation, supervision, ownership and bank efficiency. However, there has been some discussion about what regression model should be used in the second stage of the DEA efficiency analysis. For example, most of the previous studies (Pasiouras, 2008; Sufian, 2009; Gardener et al., 2011; Ab-Rahim et al., 2012; Huang and Fu, 2013) used the Tobit regression to identify determinants of bank efficiency.

However, Simar and Wilson (2007), Ramalho, Ramalho, and Henriques (2010) argue that previous studies using Tobit regression do not provide data generating process and challenge the suitability of the Tobit model. Ramalho et al. (2010) suggest that fractional logit regression is the most natural way for second-stage regression. To check the regression results in the previous analysis, we apply both fractional logit regression and Tobit regression in the second stage, to examine the relationship between regulation, supervision, ownership and bank performance. The robustness check results are shown in Table 5-16. In both regressions, we use technical efficiency, scale efficiency and technology gap ratio in Model 4 as dependent variables and the same independent variables as in the previous analysis.

Columns 1 to 3 in Table 5-16 show the results of fractional logit regression and indicate similar results as in Table 5-12. Regulation and supervision are positively related to bank pure technical efficiency and technology gap ratios. Market discipline is positively associated with bank scale efficiency in the Asia-Pacific region. However, we observe that coefficients in the fractional logit regression are larger than those in the truncated regression and there are differences in the Z-value between the two types of regressions.

Columns 4 to 6 in Table 5-16 display the Tobit regression results on bank efficiency. Even though the coefficients of variables have the same signs, we observe that supervision power and market discipline are not significantly related to pure technical efficiency. All four regulation and supervision indices have positive relationships with the technology gap ratio of banks. Similar to the discussion in Section 5.4, deposit insurance schemes and state ownership are not significantly related to bank performance in both fractional logit and Tobit regression models.

Both supported by data generating progress, fractional logit regression model and bootstrap truncated regression model have provided similar results for the relationship between bank regulation, supervision, state ownership and bank efficiency. However, the different results from Tobit regression provide evidence of possible invalid interpretations when using Tobit regression in the second-stage regression model.

Table 5-16 Regression Results: Fractional Logit Regression and Tobit Regression

VARIABLES	Fractional Logit Regression			Tobit Regression		
	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio
Regulation and Supervision						
CAPITAL	0.2069***	-0.0081	0.1789***	0.0201***	0.0010	0.0164**
	(3.6605)	(-0.2649)	(2.8087)	(2.8396)	(0.1533)	(2.5060)
SPPOWER	0.0506*	0.0269*	0.1205***	0.0026	0.0043	0.0079***
	(1.7768)	(1.7727)	(3.8051)	(1.0131)	(1.1047)	(3.2451)
MKDSPL	0.4634*	0.4098**	1.0504***	0.0313	0.0680*	0.0926***
	(1.9161)	(2.3118)	(3.6772)	(1.2163)	(1.8896)	(3.3342)
ACRS	0.1274**	-0.0152	0.2119***	0.0132**	-0.0032	0.0153***
	(2.3162)	(-0.4514)	(3.1935)	(2.3242)	(-0.4276)	(2.5911)
DEP_INS	-0.0607	0.0562	-0.0130	0.0049	0.0116	-0.0011
	(-0.6188)	(0.7962)	(-0.1182)	(0.4296)	(0.7011)	(-0.0902)
Ownership						
STATE	-0.0719	0.0565	-0.0997	-0.0103	0.0073	-0.0098
	(-0.8184)	(0.7775)	(-1.1219)	(-1.3123)	(0.9210)	(-1.2725)
Bank-specific						
BANKSIZE	0.1973***	-0.146***	0.2134***	0.0221***	-0.028***	0.0179***
	(10.6387)	(-9.7058)	(8.7663)	(15.0755)	(-18.8324)	(11.9368)
EQTA	2.5618***	0.8073**	2.2581***	0.2827***	0.0929**	0.1958***
	(5.8482)	(2.4078)	(4.6255)	(7.5429)	(2.4482)	(5.5274)
LIQTA	-0.6041**	0.1807	-0.6323**	-0.082***	0.0269	-0.077***
	(-2.2406)	(0.9800)	(-2.0175)	(-2.8372)	(1.1919)	(-2.8936)
Country-specific						
GDP_growth	0.0168	-0.0036	0.0172	0.0033***	-0.0002	0.0051***
	(1.3993)	(-0.5275)	(1.2214)	(2.5957)	(-0.1132)	(3.9388)
INF	0.0102	0.0200***	-0.031***	0.0019*	0.0032***	-0.004***
	(1.4189)	(3.7307)	(-3.5093)	(1.8685)	(2.8496)	(-4.3943)
HHI	0.7608	0.5872*	-0.0714	0.0670	0.0585	0.0087
	(1.2715)	(1.6500)	(-0.1111)	(1.4434)	(1.0167)	(0.2193)

PrCrGDP	-0.0075**	0.0000	-0.0071**	-0.001***	-0.0001	-0.0006**
	(-2.4916)	(0.0279)	(-2.0615)	(-3.2615)	(-0.4575)	(-2.5366)
institutional_env	-0.1883	-0.2061**	-0.1553	-0.0441**	-0.0287	-0.0086
	(-1.3395)	(-2.0546)	(-0.8973)	(-2.1493)	(-1.2977)	(-0.4657)
Constant	-4.4315**	1.4683	-9.105***	0.3335*	0.8862***	-0.0705
	(-2.1735)	(1.0551)	(-3.6945)	(1.6557)	(3.0197)	(-0.3283)
Sigma				0.0810***	0.0958***	0.0755***
				(39.7257)	(56.2804)	(34.1237)
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports the relationship between bank regulation and supervision on efficiencies of banks using fractional logit regression (column 1-3) and ordinary least square regression (column 4-6). Z-values are shown in the parenthesis. PTE, SE, and TGR estimates from Model 4 are used as the dependent variables. Statistically significance at 10% level. *, **,*** indicates 10%, 5% and 1% levels of significance, respectively.

Source: Author's calculations

5.6 Conclusion

Using the bootstrap DEA approach, we estimate technical efficiency, pure technical efficiency, and scale efficiency of banks in the Asia-Pacific region. To capture the impact of off-balance sheet activities on bank efficiency estimation, we compare efficiencies estimated using different input and output specifications, and find that including off-balance sheet activities as one of the outputs, has a significant impact on bank technical efficiency and scale efficiency. For example, omitting OBS activities underestimate the technical efficiency estimates and overestimate scale efficiency of banks in the Asia-Pacific region.

Using O'Donnell et al. (2008)'s idea of meta-frontier and group-frontier, we define each country into groups and estimate bank efficiency relative to the group-frontier and meta-frontier. Therefore, we obtained the group-frontier PTEs, meta-frontier PTEs, and technology gap ratios for Asia-Pacific banks. Compared to banks in other countries, an average Indonesian bank perform further away from its group-frontier, suggesting banks can reduce large portion of inputs to be efficient using the available technology in Indonesia. In contrary, our sample Singaporean banks operate on the group frontier, indicating that they operate efficiently using domestic technology.

Relative to the meta-frontier, we are able to compare bank efficiency across countries. On average, Australian banks have the highest pure technical efficiency, while Indonesian banks have the lowest, among banks in the Asia-Pacific region. Moreover, our results suggest that Japanese production frontier lies closest, while the Indonesian production frontier lies furthest to the meta-frontier. In other words, the Japanese banking industry has more sophisticated technology while the Indonesian banking industry has the least advanced technology, compared to other countries in the Asia-Pacific region.

Our results of the second-stage regression indicate that bank regulation and supervision are positively related to bank efficiency from 2005 to 2014. However, when considering the impact of regulation and supervision on different-sized banks, we find that smaller banks benefit more from stricter regulation and supervision than other types of banks. From 2005 to 2008, bank regulation and supervision are negatively related to bank efficiency except for official supervisory power. After the 2008 GFC, most regulation and supervision (except capital regulation) are positively associated with technology gap ratios. These findings can provide valuable information for regulatory authorities in the Asia-Pacific region and enable them adapt current bank regulation and supervision policies according to the bank sizes, and changes in macroeconomic conditions.

Chapter 6

Conclusion

6.1 Introduction

Chapter 6 summarises the main findings of the study. Section 6.2 describes the results in relation to the research objectives and provides policy implications based on the empirical results. Section 6.3 discusses the limitation of the study. This is followed by proposed future research direction in section 6.4.

The banking industry in the Asia-Pacific region has grown strongly over the last two decades. Since the 1970s, financial sectors in the Asia-Pacific region have undergone deregulation and reforms. However, these reforms brought not only fast development but also led to the asset bubble burst in the 1980s and the Asian Financial Crisis in 1997. Following these financial crises, the governments in the Asia-Pacific region introduced restructuring programmes to stabilise the financial system. In the early 2000s, the banking industry in the Asia-Pacific region started to grow rapidly and is now an essential part of the global financial market. Most of the financial markets are highly bank-dominated and concentrated in the Asia-Pacific region.

Due to historical developments in the Asia-Pacific banking industry and government interventions after the 1997 Asian financial crises, the banking industries in the Asia-Pacific region have relatively high state ownership than other countries/regions. During the most recent 2008 GFC, the Asia-Pacific banking industries demonstrated high levels of resilience, particularly in comparison to the US and the European countries. Conservative regulation and supervision, low exposure to subprime assets in the Asia-Pacific banking industry are regarded as responsible for their strong performance.

None of the previous studies have considered the unique characteristics of the Asia-Pacific banking industry nor examined the relationship between bank regulation, supervision and bank performance since the 2008 GFC. This study contributes to the existing literature through focusing on the impact of including off-balance sheet activities in efficiency estimations and examines the relationships between bank regulation, supervision, state ownership and bank efficiency in the Asia-Pacific region.

6.2 Summary of Findings for the Research Objectives

The current study used 2186 bank-year observations from 333 banks from eight Asia-Pacific countries to estimate bank efficiencies. More specifically it examined the relationship between bank regulation, supervision, state ownership and bank efficiency from 2005 to 2014. The main research objectives of this study were : (1) to identify whether the inclusion of off-balance sheet activities had

a significant impact on bank efficiency measurements in the Asia-Pacific region; (2) to investigate whether bank regulation and supervision improved or reduced bank efficiency in the Asia-Pacific region; (3) to examine whether state ownership is significantly related to bank efficiency in the Asia-Pacific region. To answer the research objectives, this study employed the double bootstrap DEA approach (Simar and Wilson, 2007) to estimate bank efficiency and explore the relationship between regulation, supervision, and ownership and bank efficiency. In addition to the technical efficiency and scale efficiency, this study followed O'Donnell et al. (2008) study to estimate the technology gap ratio for each bank and evaluate the gap between the technology of each banking industry and the technology for the Asia-Pacific region as a whole.

6.2.1 Research Objective One

Even though previous studies of bank efficiency estimation have recognised the increasing importance of off-balance sheet (OBS) activities in the bank industry, most of the studies (Radic, Fiordelisi, and Girardone, 2012; Sufian et al., 2012, etc.) have directly included OBS activities as one of the outputs. While a few studies (see for example, Pariouras, 2008; Lozano-Vivas and Pasioura, 2010) have examined the impact of incorporating OBS activities in efficiency estimations, they have provided mixed results. Most analyses have examined profit efficiency, cost efficiency, or Malmquist productivities. No studies have conducted research on technical efficiency and scale efficiency in the Asia-Pacific banking sectors.

For research objective one, both traditional and bootstrap DEA approaches were employed to estimate bank efficiency with four different input and output specifications. The base (Model 1) did not include OBS activities; Model 2 considered OBS activities; Model 3 considered risk but excluded OBS activities; and Model 4 included risk as well as OBS activities. To identify the impact of incorporating OBS activities in bank efficiency estimations, we compared Models 1 and 2, as well as Models 3 and 4, to investigate if there were any significant differences between efficiencies estimated from the models. There were three types of efficiency estimates used for comparisons: overall technical efficiency, pure technical efficiency, and scale efficiency.

After comparing the average values of each model, we observed that technical efficiencies including OBS activities were higher, but that scale efficiencies were lower than those which did not consider OBS. Kruskal-Wallis tests indicated that differences between the bank efficiencies were significantly different from zero. Furthermore, we employed the Skillings-Mack test for efficiencies from four models. The results suggested that technical efficiencies which incorporated OBS activities were significantly higher than those which did not consider OBS. However, the scale efficiencies using OBS activities were lower than those without OBS activities.

6.2.2 Research Objectives Two and Three

The meta-frontier pure technical efficiency, scale efficiency, and technology gap ratio of banks in the Asia-Pacific region were used as dependent variables in the bootstrap truncated regression models to examine the relationship between regulation, supervision, state ownership and bank efficiency. This study found that from 2005 to 2014, Australian banks were the most technically efficient, followed by banks in Hong Kong and Japan. Indonesian banks exhibited the lowest technical efficiency. Based on the average level of technology gap ratio for each country, Japanese banks were found to have the most advanced technology sets, while Indonesian banks were found to have the least sophisticated technology sets. However, the Indonesian banks were found to have the most scale efficiency, while Thai banks were the least scale efficient.

For research objective two and three, we conducted regression models for the full samples as well as sub-samples. Firstly, we used the full sample to examine the overall relationship between bank regulation, supervision, state ownership and bank efficiency (pure technical efficiency, scale efficiency, and technology gap ratio) from 2005 to 2014. Secondly, we divided banks into three groups according to their total assets (as small, medium, and large banks) and analysed the relationship between regulation, supervision, state ownership and bank efficiency for different-sized groups. Lastly, we explored the relationship between regulation, supervision and bank efficiency for two different study time periods (2005-2008 and 2009-2014).

6.2.2.1 Research Objective Two

The existing studies that examine bank regulation and supervision have focused mostly on capital regulation. As bank regulation and supervision data became available, more researchers started to consider the impact of overall regulation and supervision on bank performance. Recent cross-country studies provided inconclusive empirical results. Our research focused on the three pillars of the Basel Accord (that is, capital regulation, official supervisory power, and market discipline) and activity restrictions as regulatory and supervisory indicators in the banking industry.

Using the full sample of 2186 bank-year observations, we identified significantly positive relationships between regulation, supervision and bank efficiency. All four of the regulation and supervision indicators are positively associated with bank pure technical efficiency and technology gap ratio. Furthermore, market discipline was found to be positively related to bank scale efficiency. Other regulatory and supervisory policies were not significantly related to scale efficiency.

After conducting the bootstrap truncated regression for sub-samples of different-sized bank groups, our results showed that small-sized banks' efficiencies are affected by regulation and supervision more than other bank groups. Official supervisory power affects large banks' efficiency positively.

Additionally, none of the regulation and supervision policies is related to the efficiency of medium-sized banks.

The regression results of the subsample of the two study time periods indicate that bank regulation and supervision have mixed effects on bank efficiency during different time periods. Before and during the financial crisis, bank regulation and supervision are mostly negatively related to bank technical efficiency and technology gap ratio. Official supervisor power is the only regulatory indicator positively related to bank technical efficiency and the technology gap ratio. Furthermore, the deposit insurance scheme is negatively related to bank performance over the first study period (from 2005 to 2008).

After the 2008 GFC, capital regulation showed a significant negative relationship with bank technology gap ratio, and official supervision power, market discipline, activity restrictions are positively associated with the technology gap ratio. Furthermore, higher capital regulations and stricter market discipline are related to higher scale efficiency, while more supervisory power and activity restrictions are linked to lower scale efficiency from 2009 to 2014.

6.2.2.2 Research Objective Three

Even though most previous studies have provided evidence of the adverse impact of state ownership in the banking industry, our results suggested that state ownership is not significantly related to bank efficiency in the Asia-Pacific region. Our results is similar to Barry et al. (2008)'s finding in the Asian banking industry that state-owned bank efficiency is not significantly different from privately-owned banks. After calculating the average efficiency for state-owned banks and non-stated-owned banks, we found that the average overall technical efficiency, pure technical efficiency, scale efficiency of state-owned banks is lower than other banks. This lower average efficiency of the state-owned banks in the Asia-Pacific region might be due to the fact that developing countries have more state-owned banks than developed countries, rather than that banks being state-owned.

6.3 Policy Implications

Given banking industries' central role in domestic financial systems in the Asia-Pacific region, it is essential for banks to operate efficiently in allocating financial resources in the country. Our results have highlighted the impact of including the non-traditional activities when measuring bank efficiency. Our study provides important advice for policymakers, bank managers, and potential investors of banks who are concerned with bank efficiency. For policymakers, precise information relating to bank performance is needed for policy-making decisions (such as capital requirements and disclosure of off-balance sheet activities). Since banks might not be equally efficient in all types of businesses, including off-balance sheet activities, efficiency measurements could affect managers'

operating decisions. For potential investors, correctly-estimated bank efficiency can reveal a bank's true value and their potential investment return in the future. Researchers who may not be able to access information about off-balance sheet activities information, must bear in mind that omitting off-balance sheet activities will lead to understating technical efficiency and overstating scale efficiency of banks in the Asia-Pacific region.

Our primary results demonstrate that regulation and supervision are associated with better bank performance in the Asia-Pacific region. More specifically, for bank regulatory authorities, regulation and supervision policies should be revised to reflect the current conditions. Before and during financial crisis periods, regulatory authorities should implement policies such as lower capital stringency, lower market discipline, and less nonbank activity restrictions to encourage better bank performance. While in the post-crisis periods, bank regulatory authorities can apply stricter regulation and supervision to improve bank production technology and move the production frontier closer to the technology of the entire Asia-Pacific region. Bank regulatory authorities should thus impose less restrictive regulations on banks in the pre-crisis and crisis periods, and stricter regulation and supervision in post-crisis periods to improve bank efficiency and production technologies in the Asia-Pacific region. Potential investors must pay attention to the smaller and large banks which could benefit with better performance from conservative regulation and supervision regimes in the Asia-Pacific countries.

After the 1997 AFC and 2008 GFC, the restructuring programmes in each country created a higher level of the state ownership in the banking industries in the Asia-Pacific region. While state ownership is typically used as a risk management strategy, our findings have demonstrated that government ownership does not have an adverse impact on bank performance. For potential investors and researchers, state ownership should not be a major concern when making investment decisions in relation to Asia-Pacific banks.

6.4 Limitations of the Study

Even though we aim to provide comprehensive and precise insight in the banking industry in the Asia-Pacific region, it is important to acknowledge drawbacks in our study in terms of our efficiency estimation approach, data selection and construction.

6.4.1 Limitations in the Efficiency Estimation Approach

The first limitation arises from the bank efficiency estimation approach employed in this study. As discussed in Chapter 4, the non-parametric approach has both advantages and disadvantages compared to the parametric approach. One of the disadvantages of the DEA approach is that the random error is assumed to be zero when constructing the frontier of the sample banks. This error

has the ability to affect efficiency measurements. Even though the double bootstrap DEA approach is used to provide the bias-corrected efficiency measurement for banks in the Asia-Pacific region, the efficiency could still be affected by unobserved measurement errors.

Moreover, it is unclear whether the intermediation approach is better than the production approach and there has been some controversy over input and output selection. Due to missing data about a large number of banks in our sample, non-interest expense was used to represent human capital input to estimate bank efficiency. As a result, there could be bias in our estimated efficiency scores due to our data selection. In addition, we estimated technical efficiency in order to measure banks' abilities to use minimal input to produce output without considering the input and output prices. Therefore, our results provide limited information for researchers who aim to measure cost minimisation and profit maximisation.

Another limitaion linked to the estimation approach is the interpretaion of effciency over the study period. Even though we estimated bank efficiency from 2005 to 2014, the increase (decrease) of bank efficiency scores do not indicate that banks are more (less) efficient over time. In fact, decreases in bank efficiency score can be caused by a decline in bank production technologies (that is, the frontier does not move while bank production moves away from the frontier), or the improvement of the frontier (that is, bank production remains the same while the frontier is improved and moves away from the bank production). Therefore, interpretations of efficiency changes over time should be cautious and consider possible causes. Alternatively, different efficiency estimations should be conducted to obtain further information about changes in bank efficiency in the Asia-Pacific region.

6.4.2 Data Collection and Variable Constructions Limitations

The second limitation is associated with data collection in terms of state ownership and bank regulation and supervision. The data of state ownership, one of our most important variables, was collected manually, based on ownership data from the BvD Bankscope database and the official websites of major bank shareholders. Since most of the companies do not provide adequate information about their shareholders, especially those in developing countries, it was difficult to track down the ultimate owners of banks. This limitation might be resolved if researchers have access to other databases in the future.

Another data collection problem was related to the regulation and supervision database. As discussed in Chapter 4, the regulation and supervision data was obtained from the Bank Regulation and Supervision Survey in 2007 and 2011. The timeliness and frequency of the data could limit result

interpretations. However, there is no better available data sources for regulation and supervision for our cross-country study.

Furthermore, due to data availability (data was obtained from the BvD Bankscope and Bank Regulation and Supervision survey), our sample contained banks from eight countries in the Asia-Pacific region, of which, five are developed countries. Even though these countries can be used to capture the diversity and common characteristics of the Asia-Pacific banking industries, questions remain as to whether our results can be applied to all banks in the Asia-Pacific region.

6.5 Future Research

Our study fills gaps in previous studies by providing a comprehensive bank efficiency estimations. It shed light on the relationship between bank regulation, supervision, state ownership and bank efficiency in the Asia-Pacific region. We offer the following suggestions for future research on this topic.

To avoid potential estimation errors in efficiency estimation, efficiency estimated stochastic frontier analysis could be used to provide additional information regarding banking industries in the Asia-Pacific region. Furthermore, information on input and output prices should be included in future studies to estimate the cost efficiency, profit efficiency, or revenue efficiencies as supplementary to the current research. Thus, bank efficiency could be comprehensively measured in terms of a bank's ability to convert input to output, input and output allocations, and profit maximisation. Except for different efficiency measurements, Malmquist productivity indexes for the Asia-Pacific banks could also be estimated to provide more information about efficiency changes over time.

Future research could also include more countries in the Asia-Pacific region. Through expanding the research context, future research could examine whether the positive impact of regulation and supervision on bank efficiency remain significant in other banking industries in the Asia-Pacific region. Further, more robust results could be obtained by considering banking industries with various development levels and regulatory regimes in the future. For the state ownership data collection, future research could use more detailed information to track down the ultimate ownership of the banks. Based on the ownership information, additional ownership variables such as foreign ownership, family ownership, and widely-held ownership could be used in the future to capture the impact of ownership structure on bank efficiency. Regarding regulation and supervision data, future studies could collect data from individual countries' regulatory laws and rules to investigate the relationship between regulation, supervision, and bank performance with more recent and more frequent data.

Appendix A

Table A-1 Bank Regulation and Supervision Survey Questions for Selected Variables

Regulation and Supervision	Survey Questions
Capital Stringency	1. Is the minimum capital-asset ratio requirement risk-weighted in line with the Basel guidelines? 2. Does the minimum ratio vary as a function of an individual bank's credit risk? 3. Does the minimum ratio vary as a function of market risk? 4. Does the minimum ratio vary as a function of operational risk? 5. Before minimum capital adequacy is determined, which of the following are deducted from the book value of capital: (a) market value of loan losses not realised in accounting books; (b) unrealised losses in securities portfolios? (c) Unrealised foreign exchange losses?
Official Supervisory Power	1. Does the supervisory agency have the right to meet with external auditors to discuss their report without the approval of the bank? 2. Are auditors required by law to communicate directly to the supervisory agency on any presumed involvement of bank directors or senior managers in illicit activities, fraud, or insider abuse? 3. Can supervisors take legal action against external auditors for negligence? 4. Can the supervisory authority force a bank to change its internal organisational structure? 5. Are off-balance sheet items disclosed to supervisors? 6. Can the supervisory agency order the bank's directors or management to constitute provisions to cover actual or potential losses? 7. Can the supervisory agency suspend the directors' decision to distribute dividends? 8. Can the supervisory agency suspend the directors' decision to distribute bonuses? 9. Can the supervisory agency suspend the directors' decision to distribute management fees? 10. Can the supervisory agency legally declare – such that this declaration supersedes the rights of bank shareholders – that a bank is insolvent? 11. Does the Banking Law give authority to the supervisory agency to intervene; that is, to suspend some or all ownership rights ina problem bank? 12. Regarding bank restructuring and reorganisation, can the supervisory agency or any other government agency supersede shareholder rights? 13. Regarding bank restructuring and reorganisation, can the supervisory agency or any other government agency remove and replace management? 14. Regarding bank restructuring and reorganisation, can the supervisory agency or any other government agency remove and replace directors?
Market Discipline	1. Is subordinated debt allowable (or required) as part of capital? 2. Are financial institutions required to produce consolidated accounts covering all bank and any non-bank financial subsidiaries? 3. Are off-balance sheet items disclosed to the public? 4. Must banks disclose their risk management procedures to the public? 5. Are directors legally liable for erroneous/misleading information? 6. Do regulations require credit ratings for commercial banks? 7. Does accrued, though unpaid interest/principal enter the income statement while the loan is non-performing?
Activity Restriction	For each nonbank activity, regulatory authorities assign an answer using 1 (unrestricted); 2 (permitted); 3 (restricted); 4 (prohibited). 1. Underwriting, brokering and dealing in securities, and all aspects of the mutual fund industry;

2. Insurance underwriting and selling;
3. Real estate investment, development, and management.

Source: Bank Regulation and Supervision Survey (2007, 2011).

Table A-2 Laws and Official Documents of Bank Regulation and Supervision in Japan and Singapore

Country	Name of Laws and Official Documents
Japan	1. Banking Act (Ordinance of the Ministry of Finance, No,10 of March 31, 1982) 2. Basel III Regulatory Consistency Assessment (Level 2) Japan (Basel Committee on Banking Supervision, 2012) 3. Financial Instruments and Exchange Act (effective April 1, 2008) 4. Financial Inspection Rating System (Financial Services Agency, 2007) 5. Japan: Basel Core Principles for Effective Banking Supervision-Detailed Assessment of Compliance (IMF, 2012) 6. Japan's Financial Regulatory Responses to the Global Financial Crisis (Harada et al., 2015)
Singapore	1. MAS[20]'s Framework for Impact and Risk Assessment of Financial Institutions (MAS, 2015) 2. MAS Notice 612: Credit Files, Grading and Provisioning (MAS, 2005) 3. MAS Notice 637: Notice on Risk Based Capital Adequacy Requirements for Banks Incorporated in Singapore (MAS, 2016) 4. Monetary Authority of Singapore Act; Detailed Assessment of Compliance-Basel Core Principles for Effective Banking Supervision (IMF, 2013)

Notes: Laws and official documents were obtained from the official website of regulatory authorities and IMF official websites.

[20] MAS: Monetary Authority of Singapore.

Table A-3 Governance Index Definition and Source

VARIABLES	Definition	Source
Control of Corruption	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as “capture” of the state by elites and private interests	Worldwide Governance Indicators
Government Effectiveness	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Worldwide Governance Indicators
Political Stability and Absence of Violence/Terrorism	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	Worldwide Governance Indicators
Regulatory Quality	Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	Worldwide Governance Indicators
Rule of Law	Rule of Law captures perceptions of the extent to which agents have confidence in, and abide by, the rules of society, and in particular, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	Worldwide Governance Indicators

Table A-4 Meta-frontier Pure Technical Efficiencies using Bootstrap DEA Approach

	Traditional Efficiency	Bias-corrected Efficiency	Bias	Confidence Interval (5%)-Lower Bound	Confidence Interval (5%)-Upper Bound
Model 1					
Australia	0.9042	0.8569	0.0473	0.8152	0.8985
China	0.8045	0.7595	0.0450	0.7170	0.7994
Hong Kong	0.8717	0.8380	0.0338	0.8021	0.8673
Indonesia	0.7177	0.6750	0.0427	0.6324	0.7136
Japan	0.9070	0.8652	0.0417	0.8247	0.9021
New Zealand	0.8844	0.8246	0.0598	0.7642	0.8785
Singapore	0.8475	0.8071	0.0404	0.7648	0.8431
Thailand	0.8685	0.8279	0.0406	0.7928	0.8638
Model 2					
Australia	0.9295	0.8768	0.0526	0.8238	0.9254
China	0.8686	0.8110	0.0576	0.7425	0.8644
Hong Kong	0.9329	0.8841	0.0489	0.8274	0.9290
Indonesia	0.7403	0.6988	0.0414	0.6495	0.7371
Japan	0.9086	0.8714	0.0372	0.8300	0.9050
New Zealand	0.8997	0.8380	0.0617	0.7675	0.8954
Singapore	0.8946	0.8481	0.0465	0.7937	0.8907
Thailand	0.9143	0.8681	0.0462	0.8193	0.9104
Model 3					
Australia	0.9063	0.8711	0.0353	0.8317	0.9034
China	0.8839	0.8407	0.0431	0.7923	0.8803
Hong Kong	0.8723	0.8334	0.0389	0.7887	0.8688
Indonesia	0.8942	0.8527	0.0415	0.8075	0.8905
Japan	0.8395	0.7874	0.0521	0.7358	0.8344
New Zealand	0.8204	0.7686	0.0518	0.7212	0.8148
Singapore	0.7890	0.7401	0.0489	0.6970	0.7838
Thailand	0.8434	0.7842	0.0592	0.7283	0.8380
Model 4					
Australia	0.9588	0.9039	0.0549	0.8381	0.9555
China	0.8800	0.8245	0.0555	0.7500	0.8768
Hong Kong	0.9498	0.8958	0.0540	0.8235	0.9466
Indonesia	0.7733	0.7312	0.0421	0.6732	0.7707
Japan	0.9271	0.8847	0.0424	0.8305	0.9241
New Zealand	0.9247	0.8603	0.0645	0.7757	0.9213
Singapore	0.9258	0.8770	0.0488	0.8149	0.9227
Thailand	0.9170	0.8737	0.0434	0.8220	0.9139

Source: Author's calculation

Table A- 5 Pairwise Correlation between Independent Variables in the Regression

	CAPITAL	SPPOWER	MKDSPL	ACRS	DEP_INS	STATE	BANKSIZE	OBS	EQTA	LLPTL	LIQTA	GDP_growth	INF	HHI	PrCrGDP	INST_ENV
CAPITAL	1															
SPPOWER	0.045*	1														
MKDSPL	0.159*	-0.605*	1													
ACRS	-0.115*	0.276*	-0.195*	1												
DEP_INS	-0.028	0.443*	-0.6268*	-0.4598*	1											
STATE	0.0327	0.063*	0.0530*	0.1850*	-0.1857*	1										
BANKSIZE	0.0798*	-0.181*	0.2173*	-0.0841*	-0.0456*	0.1107*	1									
OBS	0.0323	-0.008	0.0997*	-0.0077	-0.1063*	0.0313	-0.0343	1								
EQTA	0.0531*	0.005	-0.005	-0.0643*	-0.0728*	-0.0166	-0.5176*	0.1393*	1							
LLPTL	-0.0767*	0.128*	-0.0735*	0.2122*	-0.0966*	0.1313*	-0.2009*	0.1486*	0.1034*	1						
LIQTA	0.0918*	-0.1684*	0.2815*	0.0308	-0.3004*	0.1378*	-0.2498*	0.1665*	0.2936*	0.2042*	1					
GDP_growth	0.0105	-0.123*	0.4185*	0.3590*	-0.6253*	0.2624*	-0.1484*	0.1336*	0.1739*	0.1930*	0.4659*	1				
INF	-0.048*	0.150*	-0.138*	0.3437*	-0.178*	0.2353*	-0.3816*	0.1099*	0.2590*	0.3138*	0.3962*	0.4841*	1			
HHI	-0.146*	-0.361*	0.3589*	-0.492*	-0.0829*	-0.0412	-0.0023	0.1325*	0.1539*	-0.085*	0.2369*	0.1600*	0.0737*	1		
PrCrGDP	0.1333*	-0.696*	0.6954*	-0.367*	-0.275*	-0.143*	0.4023*	0.0626*	-0.126*	-0.255*	0.0214	-0.0542*	-0.513*	0.3332*	1	
INST_ENV	-0.120*	-0.180*	-0.08*	-0.641*	0.5179*	-0.3513*	0.2866*	-0.1868*	-0.2115*	-0.379*	-0.398*	-0.6621*	-0.62*	0.302*	0.3866*	1

Notes: See Table 4-8 for definitions for variables. * indicates 5% level of significance.

Source: Author's calculation

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